Appendix E:
WAVE Radio Modules

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1 BACKGROUND

The purpose of this project was to develop a WAVE Radio Module, in accordance with the preliminary requirements (see Section 1.2), to support and enable future VSCC activities in communication protocol implementation and testing, safety application prototyping, and/or field trials. This radio module was intended to have a defined interface accessible by a variety of different computer arrangements. The radio module implements ASTM 2213-03: "Standard Specification for Telecommunications and Information Exchange between Roadside and Vehicle Systems — 5 GHz Band Dedicated Short Range Communications (DSRC) Medium Access Control (MAC) and Physical Layer (PHY) Specifications" [1] within the technical capabilities achievable with currently available hardware. ASTM 2213-03 is the lower layer standard that has been mandated by the FCC for use in the 5.9 GHz DSRC spectrum.

The materials contained in Chapters 3-7 of this report were written by the identified contractor, Denso LA Laboratories, in conjunction with the VSCC. The materials prepared by Denso comprised a number of separate specifications and reports. These were integrated into this report with minor editorial and formatting revisions.

This project was completed successfully within the planned time. Twenty second-generation WAVE radio module units were built and delivered according to the functional, hardware design and interface specifications described in this report. In addition, all radio interface Application Programming Interfaces (APIs) were provided, as well as automated software to verify API operations.

1.1 Goal

The overall goals of this project were to deliver WAVE radio modules that:

1) Provide higher layer prototyping compatibility, with APIs for application control of the radio;
2) Are robust, and usable with various computing platforms; and,
3) Offer design considerations that are likely to be cost-effective for potential medium- to large-scale field trials in the future

1.2 Preliminary Requirements for Second-Generation WAVE Radio Module

While the second-generation WAVE radio modules are not expected to be fully compliant with production automotive requirements, they must operate in the vehicle environment, as well as in various roadside locations (such as traffic signal control cabinets).

1.2.1 Functional Requirements

The major functional requirements for this project, identified on a preliminary basis, included:

1) Implement ASTM 2213-03: "Standard Specification for Telecommunications and Information Exchange between Roadside and Vehicle Systems — 5 GHz Band Dedicated Short Range Communications (DSRC) Medium Access Control (MAC) and Physical Layer (PHY) Specifications" [1] to the extent technically possible with an appropriate, currently available IEEE 802.11a chip set. The known differences from ASTM 2213-03 include:
   - Maximum transmission power in the 20 dbm range
   - Channel switching capability in less than 5 ms

2) Support the "WAVE" *ad hoc* mode:
   - Remove usage of all management frames and their associated management functions
   - In particular, no more associations

3) Support operations using 10 MHz channels in the 5.8 and 5.9 GHz bands

4) Design and implement an Application Programming Interface (API) for software control in real-time, including:
   - Channel of operation
   - Service Set Identifier (SSID)
   - Antenna switch operation mode (selection of single, dedicated antenna or two diversity antennas)
   - Power of transmission
   - Feedback from radio on Received Signal Strength Indicator (RSSI) of each received frame

1.2.2 Interface Requirements

Preliminary identification of interface requirements included:

1) Antenna connector(s)
2) Physical interface suitable for interconnection with embedded systems
3) Power, preferably automotive compatible (i.e. 12.6 volt DC)

2 DESIGN ISSUES AND DECISIONS

The initial stages of this project included several basic design decisions of major significance to the planned VSC project field testing. In most cases, the project schedule was one of the main determining factors in these decisions.

2.1 Basic Hardware Configuration

There were many different concepts discussed regarding the hardware configuration of the WAVE Radio Module. Since the use of these radio modules was to be primarily for testing purposes, size and unit cost became less consequential decision parameters. Within the compressed 18-week schedule to design and build the radio modules, it became imperative to select current, off-the-shelf hardware that would require as little modification as possible and still support the field testing requirements of the VSC project.

The decision to use a reference design Access Point (AP) card was based upon the schedule considerations, as well as the identification of the Atheros AP48 AP card that would support the necessary customization to meet the channel width, power, and frequency requirements.

2.2 Basic Interface Configuration

During the design phase of this project, the interface configuration was the focus of substantial discussion. Eventually, the embedded nature of the operating system and the limited capabilities of the processor on the AP determined that applications would more effectively need to be run on processors external to the radio module.

The decision to use an Ethernet interface to connect the radio module to the external processor (Host Device or HD), was reached by considerations of interoperability and the wide availability of Ethernet devices and drivers.

2.3 Basic Lower Layer Functionality

The decision to make the radio modules as compliant as possible with the version of the ASTM lower layer standard that had already been mandated by the Federal Communications Commission (FCC) was reached only after careful consideration of the proposals to modify the lower layer standards. The final decision was based upon the understanding that the proposed modifications to the lower layer standards were unlikely to be formally agreed in time to be incorporated into the radio modules. Even if the main concepts of the modifications were known prior to the design decision, various iterations would be expected to preclude a specific reference standard to which the radio modules could be built.

3 FUNCTIONAL SPECIFICATION

This chapter provides the Functional Specification for the WAVE Radio Module delivered in accordance with the VSC Project: Requirements for Second Generation WAVE Radio Module [Section 1.2].

3.1 Scope

This WAVE Radio Module (WRM) Functional Specification describes the WRM interface, functional, and RF performance requirements. It also provides a matrix identifying the areas of non-compliance with the ASTM E2213-03 [1] specification. The requirements in this document were derived from the VSC Project: Preliminary Requirements for Second Generation WAVE Radio Module [Section 1.2] and the ASTM E2213-03 specification.

3.2 WAVE Radio Module Interfaces

This section specifies the WRM physical interface requirements. Figure 3-1 illustrates the configuration. The WRM supports interfaces for two antennas, an Ethernet connection, and power. The WRM rear panel incorporates four connectors to support these interfaces. The subparagraphs below specify the requirements for each interface.

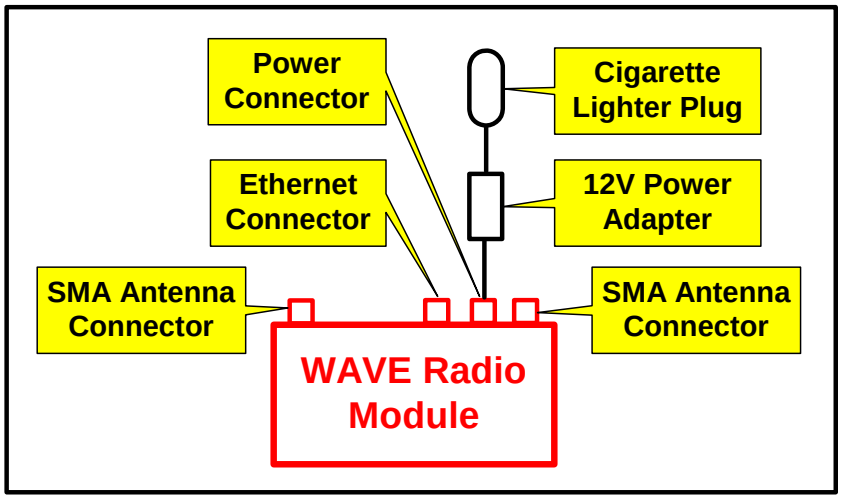


Figure 3-1. Wave Radio Module Interfaces

3.2.1 Antenna Interface

The WRM shall provide two 50-ohm chassis-mounted SMA jack (female) connectors for connecting external antennas. The antennas provide single antenna or receive diversity operation. Antennas will not be supplied with the WRM.

3.2.2 Ethernet Interface

The WRM shall provide a RJ45 jack into which a standard or crossover Ethernet cable with a RJ45 connector can be plugged. The interface shall support data rates of 10 Mbps or 100 Mbps and is used for communication between a Host Device (HD) and the WRM.

3.2.3 Power Interface

The WRM shall include a vehicle DC/DC power converter with a cable that plugs into a standard 12.6V cigarette lighter and to the WRM (5V). The WRM draws up to 2A of current at 5V.

3.3 WAVE Radio Module Functional Requirements

This section specifies the requirements for WAVE mode operation.

3.3.1 Host Device Interface

The WRM shall communicate with a HD over the Ethernet interface (see Section 3.2.2). The WRM shall support the commands and responses described in the WRM Interface Specification (Chapter 5). These commands support setting and retrieving the WRM mode, the RF configuration, and WAVE protocol parameters, as well as retrieving status. Table 3-1 lists the settable parameters that affect the functional operation of the WRM along with the specification paragraph where the effect is described. The WRM Interface Specification provides the default values for each of these parameters. Upon receiving a command to change to a new wireless mode followed by a reboot command, the WRM shall begin operation in the new mode within 10 seconds after receiving the reboot command. Upon receiving a command to change any other parameter, the WRM shall reconfigure to the new setting within 5 ms.

Table 3-1. WAVE Radio Module Functional Commands

Parameter Type	Parameter	Options	Specification Paragraph(s)
WRM Mode	Wireless Mode	WAVE or 802.11a protocol	3.3.3
	Unit Mode	Road Side Unit (RSU) or On Board Unit (OBU)	3.3.2.3, 3.3.3.2
RF Configuration	Antenna	1, 2, or Best	3.3.2.1
	Bandwidth	10 MHz or 20 MHz	3.3.2.2
	Channel	802.11a channel (in mid or upper UNII band) or WAVE channel	3.3.2.2
	Data Rate	Valid 802.11a or WAVE data rate.	3.3.2.2
	Tx Power	0 to 20 dBm or full power	3.3.2.3
WAVE Protocol	RTS/CTS threshold	Threshold in bytes	3.3.3.6

3.3.2 RF Configuration

3.3.2.1 Antenna Configuration

The WRM shall support two antennas. The WRM shall support transmit and receive on a single antenna (antenna 1 or 2), and shall also support an antenna "best" mode. In "best" mode, antenna 1 is used for transmit and receive diversity is enabled. The WRM monitors received signal strength on both antennas, and selects the receive antenna based on the strongest received signal. The antenna configuration is settable by the HD.

3.3.2.2 Channel Configuration

The WRM shall be able to tune to any WAVE channel as specified by ASTM E2213-03, and any US 802.11a channel as specified by IEEE 802.11a (except the lower UNII band channels (36-48), due to a restriction from the FCC when issuing grant). U.S. Government permission is required to transmit in the WAVE band. For WAVE channels, the WRM shall support operation at the bandwidth (10 or 20 MHz) specified by ASTM E2213-03. For 802.11a channels, the WRM radio shall support operation with either a 10 or 20 MHz bandwidth. The WRM shall support all data rates specified by

ASTM E2213-03 for channels operating with a 10 MHz bandwidth. The WRM shall support all data rates specified by IEEE 802.11a for channels operating with a 20 MHz bandwidth. The channel, channel bandwidth, and data rate are settable by the HD. Refer to the WRM Interface Specification for a complete listing of the channels, channel bandwidths, and data rates.

3.3.2.3 Transmit Power

The WRM shall support transmitting at an HD-settable power level up to nominally 20 dBm or higher if available. Due to variation in test equipment measurement, transmitter temperature changes, and 802.11 duty cycle changes, the tolerance on AP48 power output measurements is +/-1 dB or greater. For WAVE channels, the WRM shall limit the transmit power at the SMA connector so the maximum allowable level at the antenna input, as specified by ASTM E2213-03, will not be exceeded. The tolerance on the maximum limit is +/-2 dB. The maximum allowable antenna input power is a function of channel and unit mode. Refer to the WRM Interface Specification for a complete listing of the maximum allowable levels.

3.3.3 WAVE Protocol

3.3.3.1 Power-Up Initialization

Upon power-up, the WRM shall initialize to the last stored configuration.

3.3.3.2 MAC Address

When the WRM is operating in RSU mode, it shall use the last stored MAC address. When the WRM is operating in OBU mode, it shall generate a random MAC address when it powers up. The WRM will use standard C library functions to generate the random address.

3.3.3.3 MAC Frame Construction

The WRM shall construct MAC frames in accordance with IEEE 802.11 [3]. The MAC frames contain address fields which shall be set as follows:

1. To DS and From DS bits (Frame Control Field) – these bits shall both be set to 0.
2. Address 1 (Destination Address) – broadcast or unicast MAC address.
3. Address 2 (Source Address) – this field shall be set to the WRM MAC address (see Section 3.3.3.2).

4. Address 3 (Basic Service Set Identification (BSSID)) – this field shall be set to all 0s.
5. Address 4 – unused

The WRM shall always set the Power Management, More Data, and Wired Equivalent Privacy (WEP) fields to 0.

3.3.3.4 802.11 Management Frames

The WRM shall not transmit any IEEE 802.11 management frames. Upon receiving a management frame, the WRM shall acknowledge the frame but not take action based on its contents. As a result, the following 802.11 functions are not supported:

- Association/reassociation/disassociation
- Probes
- Time synchronization (beacons are disabled). This precludes the use of power save mode.
- Authentication/deauthentication
- WEP

3.3.3.5 802.11 Control Frames

The WRM shall not transmit any RTS/CTS control frames on the control channel (channel 178). On non-control channels, the WRM shall support the use of 802.11 RTS, CTS, and ACK control frames. The WRM shall not transmit any other type of control frame. As a result, operation with an 802.11 point control function (PCF) is not supported.

When transmitting on a non-control channel, the WRM shall send an RTS frame only if the MAC frame length exceeds the RTS/CTS threshold (which can be set by the HD).

3.3.3.6 802.11 Data Frames

The WRM shall support the use of 802.11 data frames with the subtype data. The WRM shall not transmit any other type of data frame.

3.3.3.7 DSRC Management Frames

The WRM will not support the DSRC management frames specified in Section 9 of ASTM E2213-03.

3.4 WAVE Radio Module RF Performance Requirements

The subsections below list the RF requirements from the VSCC preliminary requirements and ASTM E2213-03. Section 3.5 lists the WRM exceptions to these requirements.

3.4.1 General Characteristics

Table 3-2 lists the WRM characteristics.

Table 3-2. WAVE Radio Module Characteristics

Characteristic	Class	ASTM E2213-03 Reference
Regulatory Requirements	N/A	Sections 8.8.2, 8.8.3.1, and 8.9.3
Temperature	Type 1 (0 to 40°C)	Section 8.8.6
DSRC Device	Class C (Maximum Output Power of 20 dBm)	Section 8.9.2.2
Receiver Channel Rejection	Type 1	Section 8.10.2, 8.10.3

3.4.2 Transmit Requirements

Table 3-3 lists the RF transmit performance requirements.

Table 3-3. RF Transmit Performance Requirements

Parameter	Requirement
Transmit Power	The WRM shall output nominally 20 dBm or higher if available (measured at the SMA antenna connector).
Transmit Spectrum Mask	ASTM E2213-03, Section 8.9.2.
Spurious Transmissions	ASTM E2213-03, Table 7 (FCC CFR47, Part 90, I & M) **Error! Reference source not found.**.
Transmit Center Frequency Tolerance	ASTM E2213-03, Section 8.9.4.
Symbol Clock Frequency Tolerance	ASTM E2213-03, Section 8.9.5.
Transmit Modulation Accuracy	ASTM E2213-03, Section 8.9.6.

3.4.3 Receive Requirements

Table 3-4 lists the RF receive performance requirements.

Table 3-4. RF Receive Performance Requirements

Parameter	Requirement
Receiver Sensitivity	ASTM E2213-03, Section 8.10.1.
Adjacent Channel Rejection	ASTM E2213-03, Section 8.10.2.
Nonadjacent Channel Rejection	ASTM E2213-03, Section 8.10.3.
CCA Sensitivity	ASTM E2213-03, Section 8.10.4.
Multipath Delay Spread	ASTM E2213-03, Section 8.10.5.
Doppler Spread	ASTM E2213-03, Section 8.10.6.
Amplitude Variation	ASTM E2213-03, Section 8.10.7.
Rician Channel Variation	ASTM E2213-03, Section 8.10.8.

3.4.4 Synthesizer Requirements

Table 3-5 lists the synthesizer requirements.

Table 3-5. RF Synthesizer Performance Requirements

Parameter	Requirement
Channel Switching Time	< 5 ms (from VSCC Preliminary Requirements) < 2 ms (from ASTM E2213-03, Section 8.12)

3.5 ASTM E2213-03 Exception Matrix

Table 3-6 identifies the WRM exceptions to the ASTM E2213-03 requirements and the requirements where Denso performed testing to verify compliance. The compliance column identifies: compliance (C); non-compliance (N); or untested (U). If compliance is U, Denso does not have the equipment to perform the tests.

Table 3-6. ASTM E2213-03 Exception Matrix

E2213-03 Section	Requirement Summary	Com-pliance	Exceptions/Clarifications
4.1.1.2 (3)	*RSUs* RSUs may function as stations or access points (APs).	N	The WRM will operate in WAVE Ad Hoc mode. No access point management frames will be transmitted or processed in compliance with Section 4.1.1.2 (6).

E2213-03 Section	Requirement Summary	Com-pliance	Exceptions/Clarifications
4.1.1.2 (7)	*RF Measurements* RF power, sensitivity, and antenna pattern are referenced to a standard location on the vehicle.	N	The TX power output and the Rx sensitivity will be measured at the SMA antenna connector.
4.9.4, A.2.1	*Initialization* Device shall initialize to Annex A2 settings.	N	The WRM will initialize to the last stored configuration.
5.4.1	*Packet Fragmentation* *The [Frag-ACK-] frame sequence shall be supported.*	N	The WRM will not support MAC packet fragmentation. No packets will be fragmented by the transmitting WRM while in WAVE Ad Hoc mode.
6.4.2.1	*Duplicate Address Detection* If the OBU receives a frame with its own address, it selects a new MAC address. Duplicate address detection is done during association.	N	The WRM will not perform duplicate address detection. Association is not performed in WAVE Ad Hoc mode.
6.4.2.2, 7.1.5.1	*Random Number Generator* FIPS or ANSI random generators shall be used.	N	The WRM will use standard C library functions to generate the random MAC address.
7.1.1-7.1.3	*High Resolution RSSI* The device shall support high resolution RSSI mode.	N	The WRM will not support high resolution RSSI mode due to limitations of the Atheros hardware (See 8.3.1).
8.3.1, A3.1-A3.3	*RXVECTOR RSSI* RSSI resolution 0.2dB, accuracy of +/-1dB.	N	The Atheros cards report RSSI in dB with integer level resolution. High-resolution RSSI (~0.2dB) is not available. The RSSI reported by the WRM does not meet the +/- 1 DB accuracy requirement.
8.8.2, 8.8.3.1, 8.9.3	*Regulatory Requirements* US FCC requirements for operation in ITS-RS and UNII bands, including spurious emissions.	U, C	Denso does not currently have the equipment to perform the WAVE certification tests in the ITS-RS band. This requirement was not formally tested. In informal conducted emissions tests, the WRM complied with Part 90 requirements in the ITS-RS band and Part 15 requirements in the 802.11a bands.

E2213-03 Section	Requirement Summary	Com-pliance	Exceptions/Clarifications
8.8.2	*Transmit and Receive Operating Temperature* The device shall operate over the temperature range specified for its type.	U	The SOW does not require operation over any specific temperature range.
8.9.2	*Transmit Spectrum Mask* Maximum spectral density, 10MHz channels; Out-of-band max EIRP emissions.	C, N	The WRM complies with the ASTM mask for 10 MHz channels. The WRM did not comply with the 802.11a mask for 20 MHz channels on channels 175 and 181.
8.9.4	*TX Center Frequency Tolerance* Maximum tolerance of +/- 10 ppm for RSUs and OBUs.	C	The WRM complies with this requirement.
8.9.5	*Symbol Clock Frequency Tolerance* Maximum tolerance of +/- 10 ppm.	C	The WRM complies with this requirement.
8.9.6, 8.9.6.3, 8.9.7	*Transmit Modulation Accuracy* Relative constellation RMS error – also known as error vector magnitude (EVM).	N	The WRM marginally fails the EVM spec at the highest rate WAVE 64 QAM OFDM signal (27Mbps), and sometimes marginally fails at lower rates (16 and 64 QAM).
8.10.1	*Receiver Minimum Sensitivity* Lowest RSS for which reception of 1000-byte packets is greater than 90% of best-case throughput.	C	The WRM complies with this requirement.
8.10.2	*Adjacent Channel Rejection* Minimum rejection levels given for all WAVE rates.	N	The WRM adjacent channel rejection does not comply with the ASTM specs, based on type 1 requirements. The WRM passes ASTM specs at some of the higher burst rates.
8.10.3	*Nonadjacent Channel Rejection* Minimum rejection levels given for all WAVE rates.	N	The WRM non-adjacent channel rejection does not comply with the ASTM specs, based on type 1 requirements. The WRM passes ASTM specs at some of the higher burst rates.

E2213-03 Section	Requirement Summary	Com-pliance	Exceptions/Clarifications
8.10.5	*Multipath Delay Spread* <10% PER for two signals with 400 ns RMS delay spread, at 3, 6, and 12 Mbps rates averaged over 5 seconds.	U	Denso does not currently have the equipment to perform the test. This requirement will not be tested.
8.10.6	*Doppler Spread* <10% PER for a signal with max Doppler shift of +/- 2100 Hz, at 3, 6, and 12Mbps rates averaged over 5 seconds.	U	Denso does not currently have the equipment to perform the test. This requirement will not be tested.
8.10.7	*Amplitude Variation* <10% PER for a signal with 10 dB amplitude variation at 100 Hz rate, at 3, 6, and 12 Mbps rates averaged over 5 seconds.	U	Denso does not currently have the equipment to perform the test. This requirement will not be tested.
8.10.8	*Rician Channel Variation* <10% PER for signals with simulated Rician channel fading, at 3, 6, and 12 Mbps rates averaged over 5 seconds.	U	Denso does not currently have the equipment to perform the test. This requirement will not be tested.
8.11 (Table 14)	*Tx Power Levels* 64 power levels	N	The WRM will support setting power from 0 to 20 dBm in 1 dB increments. The WRM Tx output variability from the setting may be up to +/- 2 dB.
8.12	*Channel Switching Time* Channel switching time less than 2 ms.	N	The WRM supports channel switching time in under 4 ms. This is non-compliant with the ASTM spec, but meets the SOW requirement.
9	*DSRC Management Actions* Action Frame Support	N	The ASTM E2213-03 specification does not describe these requirements in sufficient detail to support implementation.
A.3.4, A.3.4.1 – A.3.4.3	*Antenna Position Calibration* Provide calibration parameters to the RSU	N	The WRM will not support transmission of antenna calibration parameters to the RSU.

4 HARDWARE DESIGN SPECIFICATION

This chapter provides the Hardware Design Specification for the WAVE Radio Module delivered in accordance with the VSC Project: Preliminary Requirements for Second Generation WAVE Radio Module [Section 1.2].

4.1 Scope

This WAVE Radio Module (WRM) Hardware Design Specification gives the rationale for selecting the 802.11a access point (AP), describes the WRM hardware and power supplies, describes WRM interfaces, and gives chipset features.

4.2 Rationale for Access Point Card Selection

Denso selected the Atheros AP48 AP card because it gave the best combination of features from the WRM 802.11 Card Selection Criteria in Table 4-1 below. The Atheros AP48 card is the latest available AP card from Atheros, and operates reliably with Atheros reference code and test tools. It provides nominally 20dBm or higher if available of maximum output power, including 1.4dB of test cable loss. The card offers a built-in Ethernet interface, and includes a MIPS processor to host the software. Denso will modify the Atheros software (SW) to operate in WAVE half-rate mode and in the WAVE frequency band. The Ethernet interface was preferred over more expensive mini-PCI and Cardbus interfaces offered by laptop-style 802.11 card designs.

Table 4-1. WRM 802.11 Card Selection Criteria

Selection Criteria	Associated Implementation Rules	AP48 Comments
Card is modifiable to operate in WAVE mode and WAVE band	Atheros is the only known source for 802.11 cards with software modifiable to operate in half-rate mode and tune to WAVE frequencies.	AP48 card is modifiable to run in WAVE mode and band.
Supports SOW schedule	Use existing 802.11 cards. Avoid design and layout of a new 802.11 card.	AP48 card is latest available card and it supports the schedule.
SW availability and documentation	Licensed Atheros code and Test SW works with their reference cards. Avoid use of commercial AP hardware and software due SW porting and OS uncertainties.	AP48 card runs with latest available Atheros code, and is modifiable.

Selection Criteria	Associated Implementation Rules	AP48 Comments
On-board processor	Implement stand-alone radio module. Avoid WLAN card drivers on host device.	AP48 includes an onboard (MIPS) processor.
Small form factor	Use a single board design; Avoid additional cards for power supply, a MIPS processor, and Ethernet driver.	AP48 card is a single board design.
Low-cost data interface to host	Use Ethernet interface; Avoid Cardbus and miniPCI interfaces.	AP48 includes an Ethernet interface.
Provide at least 20 dBm of RF output power	Most AP cards have higher RF output than Cardbus or miniPCI cards. Avoid these lower power cards.	AP48 has nominally 20dBm or higher RF output in WAVE band.
Provide two diversity antenna connections	AP cards provide two diversity antenna RF connections. Some Cardbus cards do not.	AP48 card has two diversity antenna connections.

4.2.1 Use of Commercial Access Points for the WRM

Denso investigated less expensive commercial APs for use in the WRM. The cheapest APs ($75-$200) did not use the Atheros AP chipset, but used third-party MIPS processors and Cardbus cards that typically have lower RF power output. Most of the more expensive APs ($600-$800) used the Atheros AP chipset. However, for all commercial APs, it was considered a risk to the 18-week schedule to establish vendor NDAs, procure the commercial vendor SW that runs in their third-party RTOS processors, determine the extent of vendor changes made to the Atheros code, and modify their build to develop WAVE capabilities. The key risks with commercial AP usage are uncertainties in porting the existing Denso code and a mismatch between VxWorks OS and the OS in the commercial AP.

4.2.2 Meeting Higher WAVE RF Output Power Limits

ASTM E2213-03 [1] allows for a maximum 28.8dBm output power (after cable losses). Commercial and Atheros 802.11a access points do not provide such high output power. The highest power commercial APs deliver only about 24dBm (for 802.11a, not WAVE). The WRM transmitter output power is nominally 20dBm or slightly higher in the WAVE band. Meeting these higher power ASTM limits was not a requirement of the SOW. However, Denso investigated approaches to obtain higher output power performance.

In order to use the WRM to evaluate higher output power performance called out in ASTM E2213-03, an external bi-directional amplifier (BDA) would need to be developed. It would need to operate in the WAVE band without distorting the WAVE orthogonal frequency division multiplexing (OFDM) waveforms. Currently, no vendor provides a WAVE band BDA. Denso is investigating the possibility of procuring and evaluating a modified 802.11a BDA that could work in part or all of the WAVE band.

4.3 WAVE Radio Module (WRM) Hardware Description

Figure 4-1 shows the WRM hardware elements. The WRM consists of the AP48 access point card, two RF cable assemblies and a housing (not shown), a car power supply, an office/lab power supply, and external WAVE antennas (not supplied). Front-panel LEDs identify system status, and internal connectors allow for debug and software development using RS-232 and EJTAG interfaces.

Denso will supply the radio module and the car power supply to VSCC. Although an office/lab power supply is not included in the SOW, Denso will also supply VSCC with the office/lab power supply that came with the AP48 access point. The module and power supplies are discussed in sections 4.3.1 and 4.3.2 below.

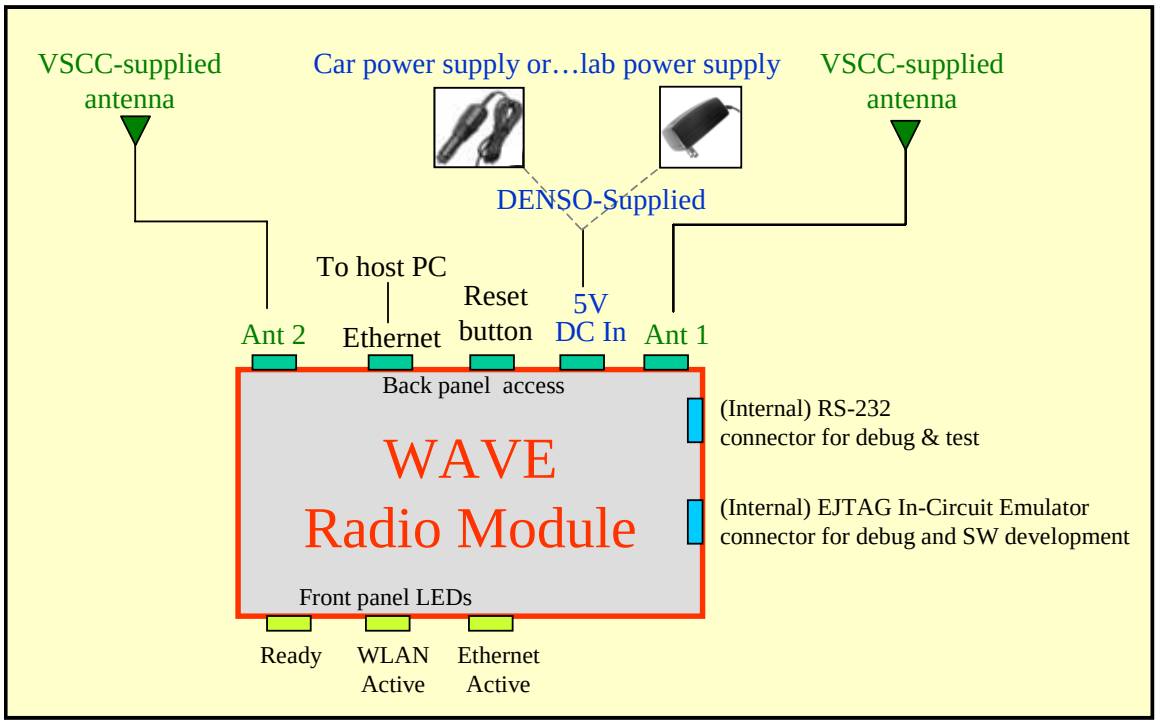


Figure 4-1. WRM Radio Module and Interfaces

4.3.1 Radio Module

Figure 4-2 shows the WRM front and rear views. The WRM supports external interfaces for two antennas, an Ethernet connection, reset button, and 5V direct-current (DC) power. The WRM rear panel incorporates the connectors to support these interfaces. The 5V DC input connector interfaces to either a car or lab supply. A dust cover for the back housing and various WRM labels are not shown.

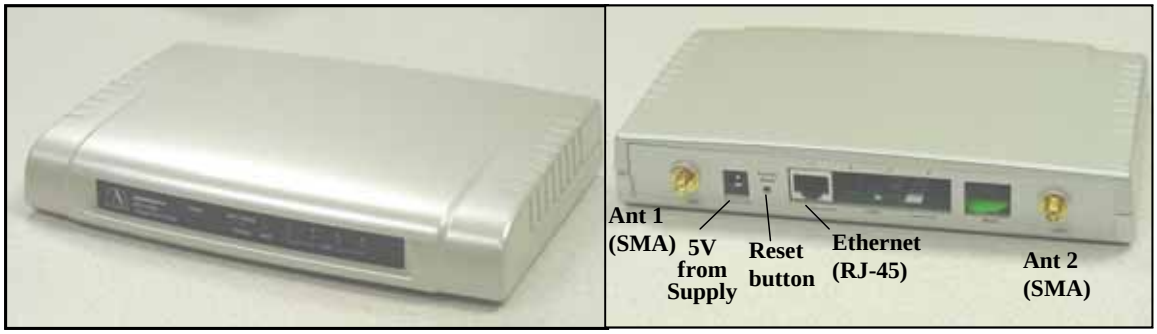


Figure 4-2. WRM Front and Rear Views

Figure 4-3 shows the AP48 card inside the WRM with two internal RF cables. One RF cable is not attached to a connector at back left. Figure 4-3 shows the location of RF connectors, RF circuit area, and Atheros MIPS/MAC processor on the card. Last, Figure 4-3 shows internal connectors for an RS-232 data interface for debug purposes (using dongle, not supplied) and an EJTAG interface, for in-circuit emulation. EJTAG is a standard developed by MIPS Technologies.

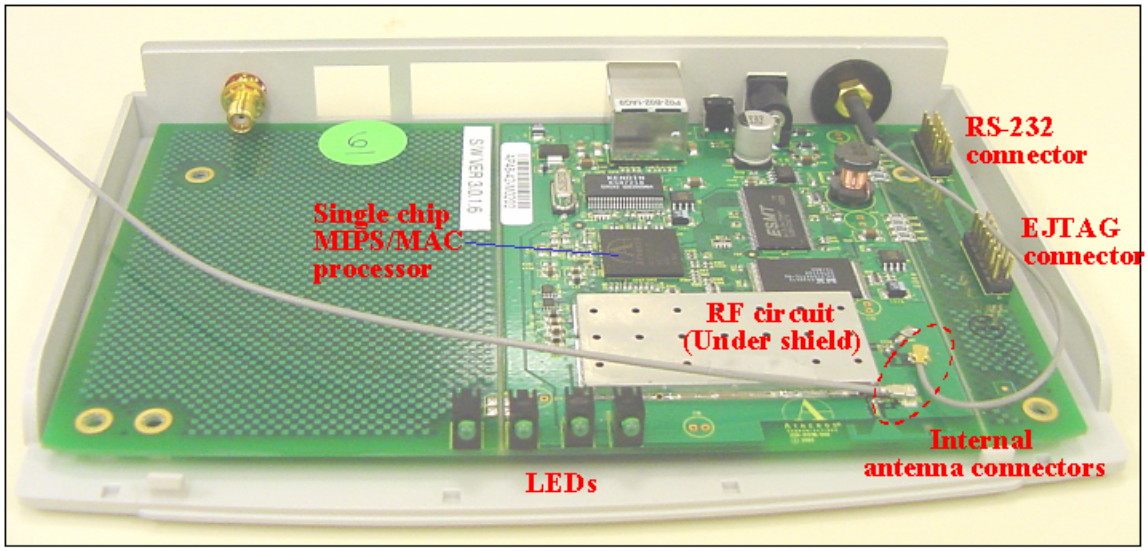


Figure 4-3. AP48 Card with RF Cables, Internal Devices and Connectors

Table 4-2 below gives the attributes of the WRM.

Table 4-2. WRM Attributes

WRM Attribute	Value or Range
FCC Certification	Certified to Part 15 for 802.11a operation. Tested at Denso for Part 90 for WAVE-band operation.
802.11-compliant modes	802.11a, WAVE
Operating frequencies	5.725-5.825GHz; 5.85-5.925GHz (WAVE)
Operating ambient temperature	0° to 40° C (typical commercial APs using Atheros chips)
RF output power (w/ cable)	16 to 20dBm* (rate-dependent), measured at SMA connector
RF TX power steps	1dB steps from 0 to 20dBm, and full power
Size with housing	7.5”W x 4.7”L x 1.25”H
Total weight (w/o DC convert)	0.6 lb
Power consumption, TX active	1.1A typical
Power consumption, RX active	0.9A typical
DC power interface	5V DC, via 5.5mm barrel connector
Ethernet interface	RJ-45 connector
Antenna interface	SMA female bulkhead connector
AP48 card size	5.2”W x 4.11”L
AP48 card type [12]	Single-sided 4 layer FR4 printed circuit board (PCB)

* The AP48 provides an output power of nominally 20dBm or higher if available. Because of variation in test equipment measurement, transmitter temperature changes, and 802.11 duty cycle changes, the tolerance on AP48 power output measurements is +/- 1dB or greater.

4.3.2 Power Supplies

Figure 4-4 shows two power supplies (converters), one of which is needed to provide 5V DC input to the WRM. The first unit is a 12V/5V DC-DC converter that includes a cigarette lighter adapter (CLA) that allows for WRM testing in a vehicle. The second unit is a 120V/5V AC-DC converter (wall cube) that allows for WRM testing in an office or lab.

Figure 4-4. Example DC-DC Converter (left) and wall cube AC-DC converter (right)

Table 4-3 gives the specs for the 12/5V DC-DC converter and the AC/DC power converter.

Table 4-3. DC-DC and AC-DC Converter Specs

Power Supply Specs	12V/5V DC-DC Converter Target Value or Range	120V AC-5V DC Converter Value or Range
Part Number	Lind DN0525-1220A	CUI Inc. DSA-0151A-05A
Input voltage	10.5V to 18V	90-132V AC
Input current	3 to 4A	0.40A (RMS) for 115V AC
Output voltage	5V DC nominal	+5V DC nominal
Output current	0 to 2.5A	0 to 2.4A typical
Voltage regulation	5% maximum	5% maximum
Line regulation	2% maximum	2% maximum
Fusing	Yes, 5A	Yes
Protection	Over current, over voltage, short circuit, under voltage	Over current, over voltage, short circuit
Operating ambient temperature	0° to 45° C typical	0° to 40° C
Size and weight	3”L x 5”W x 2”H, 0.6 lbs.	3.2”L x 2.1”W x 1.4”H, 0.4 lbs.

4.4 AP48 Interface Descriptions

The AP48 card has an internal interface for RF cable assemblies, and external interfaces for Ethernet, DC power, RS-232, antennas, and an in-circuit emulator. These interfaces are discussed beginning in section 4.4.1.

4.4.1 RF Cable Assemblies (Internal Interface)

Because the AP48 card uses micro-miniature RF coaxial connectors (see Figure 4-3) and operates up to 6GHz, Denso procured two cable assemblies to connect the two card connectors to standard SMA RF connectors on the housing. Hirose makes the card connector and cable. Denso provides and installs the cable assemblies. Table 4-4 gives the RF cable attributes.

Table 4-4. RF Cable Attributes [7]

RF Cable Attribute	Value or Range
Type	Hirose U.FL-LP-066 1.13mm diameter coaxial cable
Vendor cable part no.	RFW10531-8 (from Talley Communications)
Impedance	50 ohms nominal
Length	8 inch
Cable loss	1.2dB at 5.9GHz (typical)
Connectors	Hirose U.FL-LP-066 female plug and SMA jack bulkhead

4.4.2 Ethernet Interface

The WRM provides a RJ-45 jack for use with a standard or crossover Ethernet cable. The interface supports data rates of 10 Mbps or 100 Mbps and is used for communication between a Host Device (HD) and the WRM.

4.4.3 DC Power Interface

The WRM includes a vehicle DC/DC power converter with a cable that plugs into a standard cigarette lighter (CLA) and to the WRM. It also includes an AC/DC converter that mates to the same WRM power receptacle.

4.4.4 RS-232 Interface

The AP48 card includes an onboard connector that allows for software development and debug through a standard RS-232 serial data interface. An RS232 dongle mates to the onboard connector. The dongle can be procured directly from Atheros.

4.4.5 Antennas Interface

The WRM provides two standard 50-ohm RF SMA (SubMiniature version A) jack (female) connectors for connecting external antennas. The antennas provide single antenna or receive diversity operation. Denso does not provide antennas with the WRM.

4.4.6 In-Circuit Emulator Interface

An EJTAG interface is available for connecting an in-circuit emulator (ICE) for debug and software development purposes. The EJTAG interface directly interfaces to Wind River System's VisionICE, but also operates with other industry standard emulators and debuggers [11].

4.5 AP48 Chipset Features

Figure 4-5 shows the functions and interfaces of two primary Atheros chips in the AP48: the AR5112 dual-band RF chip and the AR2312 baseband processor chip. The AP48 card has a newer AR2313 chip to replace the AR2312. The AR2313 has the same performance as the AR2312.

4.5.1 AR5112 RF Chip Features

The design of the AR5112 RF chip allows for WAVE operation. According to the Atheros AR5112 datasheet, the AR5112 transmitter, receiver, and frequency synthesizer operate and tune to all WAVE frequencies. Software changes are needed to implement WAVE mode. The AR5112 operates in the 2.4GHz (802.11b/g) band, the 5GHz (802.11a) band, and the 5.9GHz WAVE band (with SW mods). However, software support will be disabled for 2.4GHz operation, 5.15 to 5.25 GHz operation, and for turbo mode because FCC certification of the WRM will not include these bands and mode. Figure 4-5 is a simplified view of the RF section. The AR5112 requires additional transmitter and receiver amplifiers (not shown) to achieve nominally 20dBm or higher output power [12]. In addition, Figure 4-5 does not show the antenna diversity supported by the chips.

4.5.2 AR2313 Baseband Chip Features

The AR2313 includes a built-in 32-bit MIPS R4000-class processor and wireless MAC and PHY functions. The functions for Ethernet MAC and fast UART (for RS-232) are also integrated.

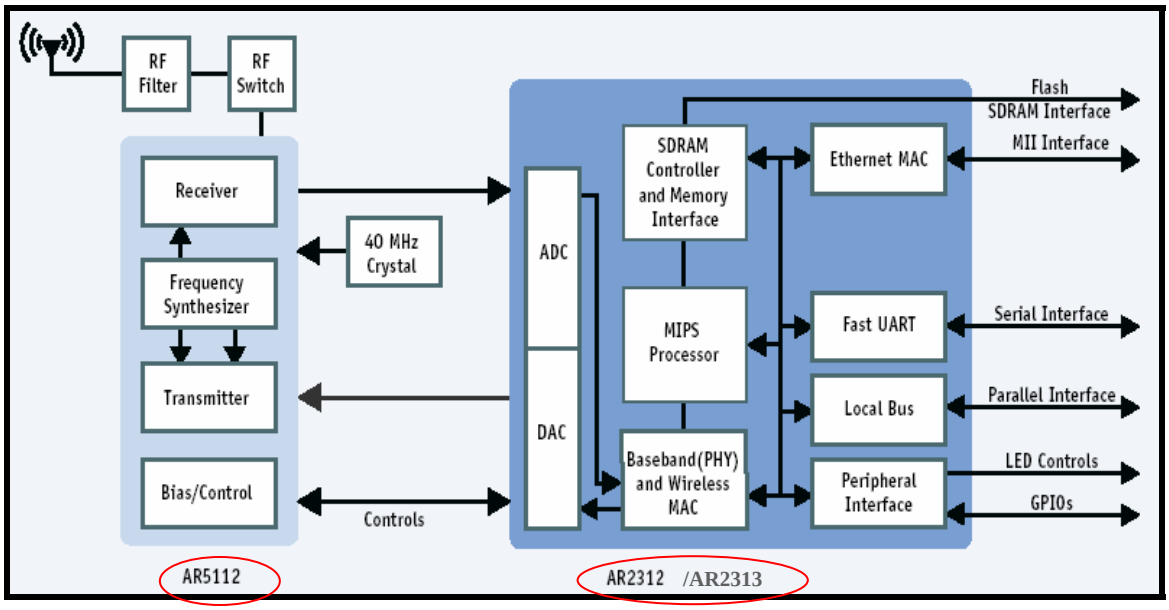
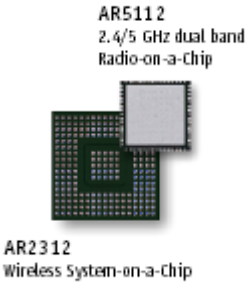


Figure 4-5. Key AP48 Atheros Chip Functions and Interfaces [5]

Table 4-5 summarizes the design features available with the Atheros AP48 chipset.

Table 4-5. Summary of AP48 Chipset Features

AP48 Chipset Features	Value or Range
Frequency Bands	US: 5.25-5.35GHz, 5.725-5.850GHz [2] **US DSRC: 5.85-5.925GHz [1]**
IEEE Data Rates: 802.11a, **WAVE mode**	1 - 54 Mbps (802.11a) [2] **3-27Mbps (WAVE 10MHz channels) [13], [14]** **6-54Mbps (WAVE 20MHz channels)**
802.11-compliant modes	802.11a, **WAVE**
Modulation Technology	OFDM with BPSK, QPSK, 16 QAM, 64 QAM;
FEC Coding Rate	1/2, 1/3, 3/4
Hardware Encryption	AES, TKIP, WEP
Quality of Service	802.11e draft
Media Access Technique	CSMA/CA
Communication Interface	MII, High Speed UART, local bus
Peripheral Interface	GPIOs, LEDs

AP48 Chipset Features	Value or Range
Memory Interface	FLASH, SDRAM
Operating temperature	**0° to 85° C (chip operating temperature range) [13], [14]**
Storage temperature range	**-60°C to 150°C [13], [14]**
Chip part numbers	**AR5112, AR2312/3**
Chip View	

5 INTERFACE SPECIFICATION

This chapter provides the Interface Specification for the WAVE Radio Module delivered in accordance with the VSC Project: Preliminary Requirements for Second Generation WAVE Radio Module [Section 1.2].

5.1 Scope

This WAVE Radio Module (WRM) Interface Specification describes the WRM setup, Telnet command interface and the Internet Protocol (IP) interface. The interface requirements in this document were derived from the VSC Project: Preliminary Requirements for Second Generation WAVE Radio Module [Section 1.2], the ASTM E2213-03 specification [1], and the Atheros AR5002 Access Point (AP) User's Guide [11].

5.2 WAVE Radio Module Attachment and Configuration

This chapter describes the procedure for connecting a Host Device (HD) to the WRM and configuring the HD IP address.

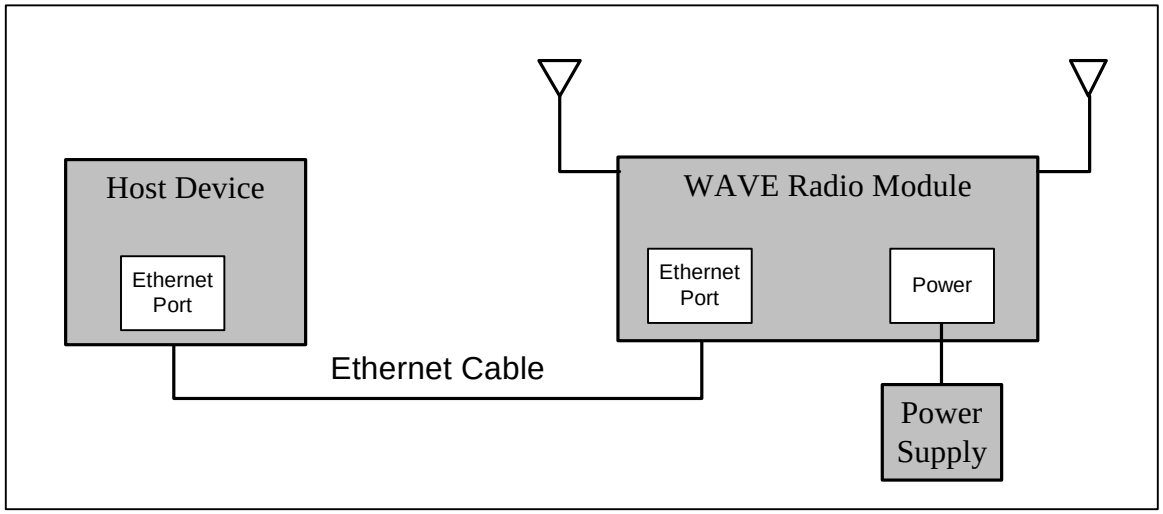


Figure 5-1. Host Device to Wave Radio Module Connection

5.2.1 WAVE Radio Module Network Connection

Connect the HD to the WRM using one of the following methods:

- Use an Ethernet crossover cable to connect the HD Ethernet port directly to the WRM Ethernet port.
- Use standard Ethernet cables to connect the HD and WRM through a hub or Ethernet switch.

Configure the HD IP address to an address of the format 192.168.001.xxx with Subnet Mask of 255.255.255.000. For communication to succeed, the HD IP address must be different from the WRM IP address (each WRM is delivered with a unique IP address of 192.168.1.0nn, where nn is the Denso assigned unit number).

5.2.2 Windows IP Configuration Example

If the HD is a PC running the Windows operating system, use the following procedure to configure the HD IP address.

- From the Host PC's Start menu, choose Settings and open the Network and Dialup Connections dialog box.
- Right click on the Local Area Connection icon that belongs to the Ethernet controller connected to the WRM and select Properties.
- Within the Local Area Connection Properties dialog box, choose Internet Protocol (TCP/IP) and click Properties.
- Configure the Host IP address to (192.168.001.xxx) for the Ethernet connection in the Internet Protocol (TCP/IP) Properties dialog box.
- Accept the settings and close the Internet Protocol Properties dialog box.
- The HD is now configured to communicate with the WRM.

5.3 WAVE Radio Module Telnet Interface

A HD configures the WRM using a Telnet Client Command Line Interface (CLI). Refer to the Telnet specification [9] for detailed requirements. The WRM supports Telnet login plus commands to get and set configuration parameters.

5.3.1 Telnet Login

To access the WRM, use the Telnet Client to log into the WRM using its IP address (e.g., Telnet 192.168.1.20). The CLI prompts for a login user name and password. After successfully entering this data, the CLI displays a version banner and prompt. The WRM is now ready to accept CLI commands as seen in Figure 5-2. Figure 5-3 illustrates the login sequence.

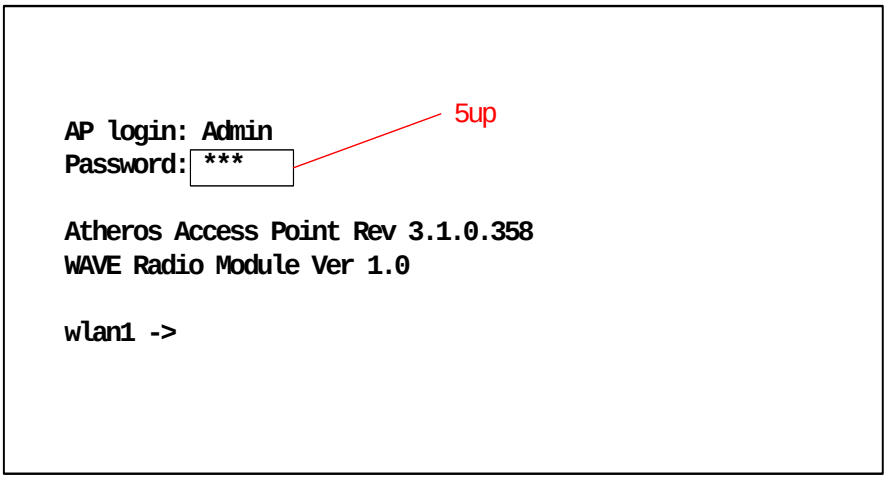


Figure 5-2. Login Screen

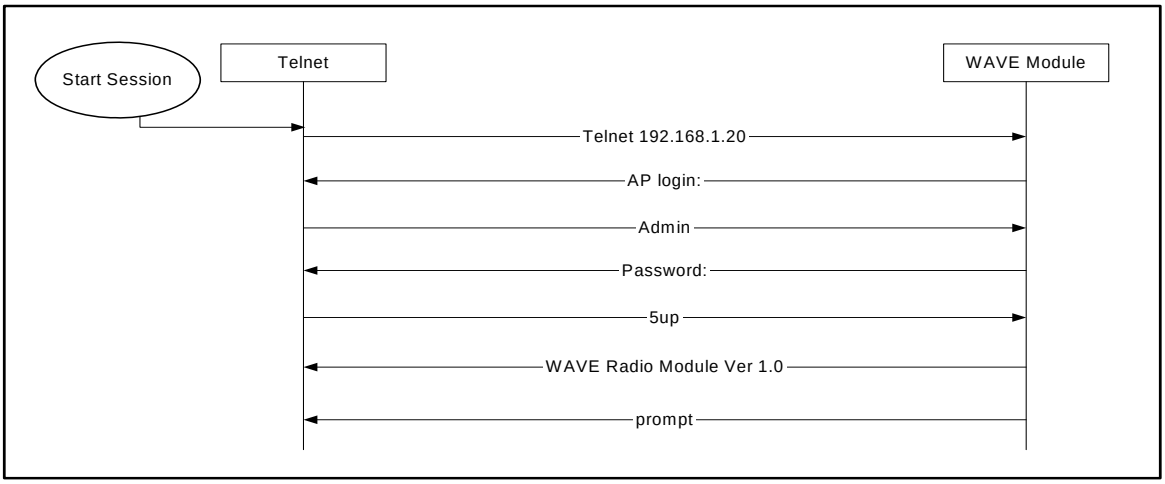


Figure 5-3. Login Sequence

5.3.2 Telnet Command Summary

Table 5-1 summarizes the Telnet WAVE commands. If the table indicates the set command requires a reboot, the HD must first send the set command and then a reboot command for the new parameter value to take effect. All commands are case insensitive.

Table 5-1. Telnet WAVE Command Summary

Command Category	Get Commands	Set Commands	Set Command Requires Reboot
Mode	get wirelessmode	set wirelessmode	Yes
	get servicemode	set servicemode	No
	get unitmode	set unitmode	No
Parameter	get antenna	set antenna	No
	get antenna1comp	set antenna1comp	No
	get antenna2comp	set antenna2comp	No
	get bandwidth	set bandwidth	No
	get fastchannel	set fastchannel	No
	get fragmentthreshold	set fragmentthreshold	No
	get power	set power	No
	get rate	set rate	No
	get rtsthreshold	set rtsthreshold	No
		set WAVEdefault	Yes
Status	get config		No
	get hardware		No
	get rssi		No
	version		No
Reboot		reboot	No

The WRM sends a response to every command.

Table 5-2 summarizes the format of the get/set commands and the response to valid commands.

Table 5-2. Set/Get Command and Response Format

Commands	Description/Parameters
get parameter	get “parameter” is used to retrieve the value of the designated “parameter”
set parameter newvalue	set “parameter” is used to set the value of the designated “parameter”
Response	**Description/Parameters**
parameter: value	The response for both the get and set commands provides the current parameter value.

If the WRM receives an invalid command or a command with an invalid or out of range parameter, it sends an error response. Figure 5-4 shows the response to an invalid command.

Figure 5-5. Invalid Command Parameter Response

Shows the response to an invalid parameter. A HD application may parse the response and check for the text “Unknown” or “Invalid” to determine if the command was rejected.

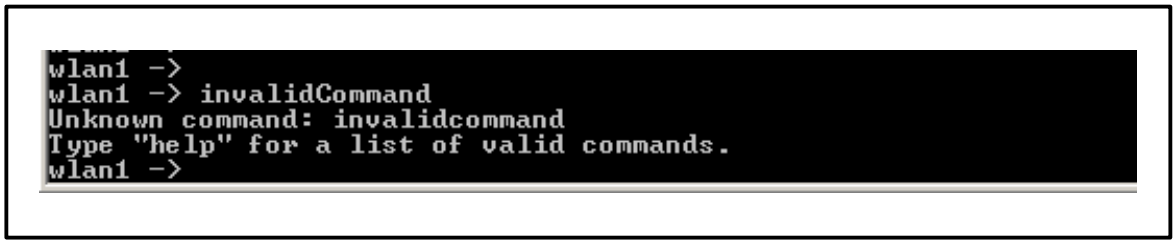


Figure 5-4. Invalid Command Response

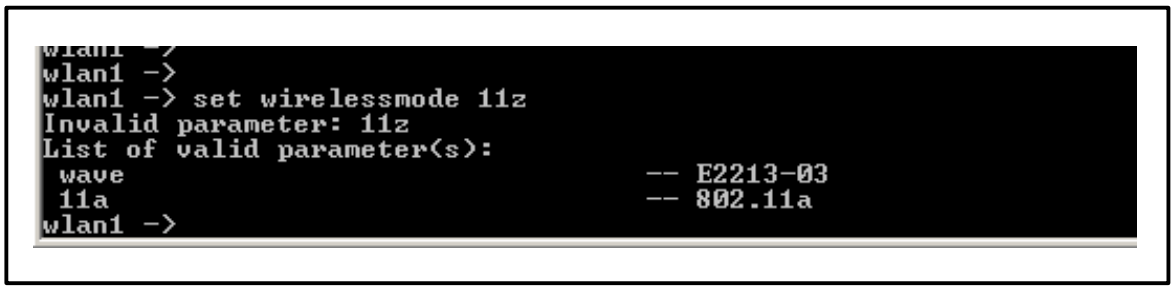


Figure 5-5. Invalid Command Parameter Response

5.3.3 Mode Commands

5.3.3.1 Get / Set Wireless Mode

This command gets or sets the WRM wireless mode (WAVE or 802.11a).

Table 5-3. Wireless Mode Command

Commands	**Description/Parameters**
get wirelessmode	Retrieve the current wireless mode
set wirelessmode wave	Begin operation in WAVE mode
set wirelessmode 11a	Begin operation in 802.11a mode
Response	**Description/Parameters**
Wireless LAN Mode: current mode	Current mode = WAVE, 11a

The following table lists the default parameter values in WAVE mode. These parameters are valid at first power up and can be modified using the CLI. The WRM saves its current configuration approximately every minute or upon a reboot command if any parameters have changed via the Telnet interface. At subsequent power ups, it will default to the last saved configuration.

Table 5-4. Default Parameter Values

Parameter	**Default Value**
Wireless Mode	WAVE
Unit Mode	OBU
Service Mode	Public Safety
Antenna	Best

Parameter	Default Value
Antenna1 Compensation	0 dB
Antenna2 Compensation	0 dB
Bandwidth (802.11a channels)	20 MHz
Channel	5890 MHz (IEEE 178) [Note: Channel 178 bandwidth is 10 MHz]
Data Rate	6 Mbps
Fragmentation Threshold	2346 bytes
Request to Send/Clear to Send (RTS/CTS) Threshold	2346 bytes
Transmit Power	20 dBm (at SMA antenna connector)

The Get/Set commands and responses described in the following sections are valid for WAVE mode. For the 802.11a mode, refer to the AR5002 AP User's Guide [5].

5.3.3.2 Get / Set Service Mode

This command gets or sets the WRM service mode (public safety or private service). This setting does not affect the current WRM functionality, but is implemented for future use.

Table 5-5. Service Mode Command

Commands	Description/Parameters
get servicemode	Retrieve current service mode
set servicemode public	Set WRM mode to public safety operation
set servicemode private	Set WRM mode to private service operation
Response	**Description/Parameters**
Service Mode: current mode	Current mode = public or private

5.3.3.3 Get / Set Unit Mode

This command gets or sets the WRM unit mode (OBU or RSU). The maximum allowable antenna input power is a function of channel and unit mode. Refer to Section 5.3.4.6 for details.

Table 5-6. Unit Mode Command

Commands	Description/Parameters
get unitmode	Retrieve current unit mode
set unitmode OBU	Set WRM to OBU mode
set unitmode RSU	Set WRM to RSU mode
Response	**Description/Parameters**
Unit Mode: current mode	Current mode = OBU or RSU

5.3.4 Parameter Commands

5.3.4.1 Get/Set Antenna

This command gets or sets the antenna configuration (best, 1, or 2). If antenna is set to best, antenna 1 is used for transmit and receive diversity is enabled. If the antenna is set to 1 or 2, the specified antenna is used for both transmit and receive.

Table 5-7. Antenna Command

Commands	Description/Parameters
get antenna	Retrieve current selected antenna
set antenna best	Transmit on antenna 1, enable receive diversity
set antenna 1	Transmit and receive on antenna 1
set antenna 2	Transmit and receive on antenna 2
Response	**Description/Parameters**
Antenna: current mode	Current mode = best, 1, or 2

5.3.4.2 Get/Set Antenna 1 Compensation

This command gets or sets the antenna 1 power compensation factor. This factor is the net gain or loss in dB between the WRM SMA connector and the antenna input due to cable losses and/or external amplifier gains. A positive value represents a gain and a negative value represents a loss. Section 5.3.4.6 describes how the WRM uses the power compensation factor to limit output power.

Table 5-8. Antenna 1 Compensation Factor Command

Commands	Description/Parameters
get antenna1comp	Retrieve the current antenna 1 power compensation factor
set antenna1comp xxx	Set antenna 1 power compensation factor to xxx dB (range = -10 thru +19)
Response	**Description/Parameters**
Antenna 1 comp: xxx dB	Current antenna 1 compensation factor in dB

5.3.4.3 Get/Set Antenna 2 Compensation

This command gets or sets the antenna 2 power compensation factor. See Section 5.3.4.3 for details.

Table 5-9. Antenna 2 Compensation Factor Command

Commands	Description/Parameters
get antenna2comp	Retrieve the current antenna 2 power compensation factor
set antenna2comp xxx	Set antenna 2 power compensation factor to xxx dB (range = -10 thru +19)
Response	**Description/Parameters**
Antenna 2 comp xxx dB	Current antenna 2 compensation factor in dB

5.3.4.4 Get/Set Bandwidth

This command gets or sets the channel bandwidth in MHz. This command is only valid for 802.11a channels (see

Table 5-13 for the list of 802.11a channels), which have a default bandwidth of 20 MHz. This command enables these channels to be used for either 10 or 20 MHz operation. Switching from 10 MHz to 20 MHz causes the WRM data rate to be doubled, while switching from 20 MHz to 10 MHz causes the data rate to be cut in half.

Table 5-10. Bandwidth Command

Commands	**Description/Parameters**
get bandwidth	Retrieve the current 802.11a channel bandwidth
set bandwidth 10	Set 802.11a channel bandwidth to 10 MHz
set bandwidth 20	Set 802.11a channel bandwidth to 20 MHz
Response	**Description/Parameters**
Channel Bandwidth: xx MHz	xx is the current bandwidth (10 or 20)

Get/Set Fast Channel

This command gets or sets the channel. Upon switching to a WAVE channel, the WRM will set the channel bandwidth to the value shown in Table 5-12. Upon switching to an 802.11a channel, the WRM will set the channel bandwidth based on the 802.11a bandwidth setting (refer to section 3.4.4 Get/Set Bandwidth). When switching from a 20 MHz to a 10 MHz channel, the WRM will halve the previous data rate. When switching from a 10 MHz to a 20 MHz channel, the WRM will double the previous data rate. The maximum allowable transmit power is a function of channel and unit mode. Refer to Section 5.3.4.6 for details. If the current transmit power setting exceeds the maximum allowed, the WRM will set the power to the maximum allowed.

Table 5-11. Fast Channel Command

Commands	**Description/Parameters**
get fastchannel	Retrieve the current channel
set fastchannel xxx	Set radio channel where xxx is one of the channel numbers specified in Table 5-12 or Table 5-13
Response	**Description/Parameters**
Radio Frequency: yyyy MHz (IEEE xxx)	yyyy is the frequency and xxx is the channel number specified in Table 5-12 or Table 5-13

Table 5-12. WAVE Channels

Channel Number	**Channel Frequency (MHz)**	**Bandwidth (MHz)**
172	5860	10
174	5870	10
175	5875	20
176	5880	10
178	5890	10
180	5900	10
181	5905	20

Channel Number	Channel Frequency (MHz)	Bandwidth (MHz)
182	5910	10
184	5920	10

Table 5-13. 802.11a Channels

Channel Number	Frequency (MHz)	Default Bandwidth (MHz)
52	5260	20
56	5280	20
60	5300	20
64	5320	20
149	5745	20
153	5765	20
157	5785	20
161	5805	20

5.3.4.5 Get / Set Fragment Threshold

This command gets or sets the MAC packet fragmentation length threshold. If the MAC frame length exceeds the threshold, the WRM will perform fragmentation. The valid range of values is 256 to 2346 bytes. This setting does not affect the current WRM functionality (no fragmentation is performed), but is implemented for future use.

Table 5-14. Fragmentation Threshold Command

Commands	Description/Parameters
get fragmentthreshold	Retrieve fragmentation threshold
set fragmentthreshold: xxxx	Set new fragmentation threshold where xxxx is the length in bytes
Response	**Description/Parameters**
Fragmentation Threshold: xxxx	xxxx is the length in bytes

5.3.4.6 Get/Set Power

This command gets or sets the transmit power in dBm (at the SMA antenna connector). The valid range is 0 to 20 dBm in 1 dB increments or full for maximum power. Full power may or may not be higher than 20 dBm.

Table 5-15. Transmit Power Command

Commands	Description/Parameters
get power	Retrieve current transmit power in dBm
set power xx	Set the transmit power to xx dBm (range = 0-20)
set power full	Set the transmit power to the maximum level
Response	**Description/Parameters**
Transmit Power: xx dBm Current Transmit Output Power yy dBm	xx is set the transmit power in dBm or full yy is the reduced transmit power, after any limiting has been applied

For 802.11a channel 64 (5320 MHz), the WRM limits the transmit output power at the SMA connector to 16 dBm, per the requirements of the FCC grant.

For WAVE channels, the ASTM E2213-03 specification [1] limits the maximum power. Table 5-16 lists the maximum antenna input power and Equivalent Isotropically Radiated Power (EIRP) where the same limit applies for all channel, unit mode, and service mode combinations. Table 5-17 lists the limits for public safety operation for channels not in Table 5-16. Table 5-18 lists the power limits for private service operation for channels not in Table 5-16.

The WRM calculates the maximum allowed output power at the SMA antenna connector based on the antenna input limits shown in the tables below and the Tx antenna compensation factor (see Sections 5.3.4.2 and 5.3.4.3). Specifically, the maximum output at the SMA connector is the antenna input limit minus the compensation factor. [Note: The EIRP values are listed for reference only. The WRM does not vary the maximum allowed output power based on service mode (i.e., public safety/private usage). As a result, Table 5-17 and 5-18 are treated identically within the WRM.]

As an example, suppose the antenna input limit for the current channel/unit mode combination is 10 dBm, antenna 1 is being used for Tx, and the antenna 1 compensation factor is +3 dB (net external gain of 3 dB). The maximum allowed output power at the SMA connector is 7 dBm. As a second example, suppose the antenna 1 compensation factor is –1 dB (net loss of 1 dB). The maximum allowed output power at the SMA connector would be 11 dBm.

If the WRM receives a set command for higher than the allowed output value at the SMA antenna connector, it will set the power to the highest allowed value. If the WRM receives a set command for lower than the allowed value, it will set the power to the specified value.

The WRM supports antenna compensation factors in the range –10 through +19 dB.

Table 5-16. Maximum Transmit Power Limits

WAVE Channel	Freq-uency (GHz)	Band-width (MHz)	RSU		OBU	
			Antenna Input (dBm)	EIRP (dBm)	Antenna Input (dBm)	EIRP (dBm)
172	5.860	10	28.8	33.0	28.8	33.0
174	5.870	10	28.8	33.0	28.8	33.0
175	5.875	20	10.0	23.0	10.0	23.0
176	5.880	10	28.8	33.0	28.8	33.0
180	5.900	10	10.0	23.0	20.0	23.0
181	5.905	20	10.0	23.0	20.0	23.0
182	5.910	10	10.0	23.0	20.0	23.0

Table 5-17. Maximum Transmit Power Limits for Public Safety

WAVE Channel	Freq-agency (GHz)	Band-width (MHz)	RSU		OBU	
			Antenna Input (dBm)	EIRP (dBm)	Antenna Input (dBm)	EIRP (dBm)
178	5.890	10	28.8	44.8	28.8	44.8
184	5.920	10	28.8	40.0	28.8	40.0

Table 5-18. Maximum Transmit Power Limits for Private Usage

WAVE Channel	Freq-uency (GHz)	Band-width (MHz)	RSU		OBU	
			Antenna Input (dBm)	EIRP (dBm)	Antenna Input (dBm)	EIRP (dBm)
178	5.890	10	28.8	33.0	28.8	33.0
184	5.920	10	28.8	33.0	28.8	33.0

5.3.4.7 Get / Set Rate

This command gets or sets the transmit data rate. For a set command, the data rate must be valid for the current channel bandwidth (10 or 20 MHz – see Section 5.3.4.4).

Table 5-19. Data Rate Command

Commands	Description/Parameters
get rate	Retrieve the current data rate
set rate xx	Set the current data rate to one of the rates specified in Table 5-20
Response	**Description/Parameters**
Data Rate: xx	xx is the data rate

Table 5-20. Data Rates

20 MHz Channel Data Rates (Mbps)	10 MHz Channel Data Rates (Mbps)
6	3
9	4.5
12	6
18	9
24	12
36	18
48	24
54	27

5.3.4.8 Get / Set RTS/CTS Threshold

This command gets or sets the RTS/CTS threshold in bytes. If the MAC frame length exceeds the threshold, the WRM will use RTS/CTS. The valid range of values is 256 to 2346 bytes. Per the ASTM E2213-03 specification [1], RTS/CTS is disabled on the WAVE control channel (channel 178).

Table 5-21. RTS/CTS Threshold Command

Commands	Description/Parameters
get rtsthreshold	Retrieve RTS/CTS threshold
set rtsthreshold: xxxx	Set the RTS/CTS threshold where xxxx is the length in bytes
Response	**Description/Parameters**
RTS/CTS Threshold: xxxx	xxxx is the length in bytes

5.3.4.9 Set WAVE Default Parameters

This command sets the WAVE parameters to the default values as specified in Table 5-4.

Table 5-22. WAVE Default Parameters Command

Commands	**Description/Parameters**
set WAVEdefault	Set the WRM to the WAVE default parameters specified in Table 5-4.
Response	**Description/Parameters**
<none>	

5.3.5 Status Commands

5.3.5.1 Get Configuration Parameters

This command gets the WRM configuration parameters.

Table 5-23. Configuration Parameters Command

Command	**Parameters**
get config	Retrieve WRM configuration parameters

The following is the list of WAVE-related parameters retrieved by the configuration command:

Table 5-24. Configuration Parameters Response

Response Parameters
Wireless Mode
Operational Mode
Wlan State
Antenna
Antenna1 Compensation Factor
Antenna2 Compensation Factor
Bandwidth
Channel/Frequency

Response Parameters
Data Rate
Fragment Threshold
RTS/CTS Threshold
Transmit Power
IP Address
Host IP address
HW Transmit Retry Limit
Service Mode
Unit Mode

5.3.5.2 Get Hardware Version

This command gets the WRM hardware version.

Table 5-25. Hardware Version Command

Command	**Description/Parameters**
get hardware	Retrieve hardware version
Response	**Description/Parameters**
wlan1 revisions: mac x.x phy y.y analog z.z PCI Vendor ID: aaaa, Device ID: bbbb Sub Vendor ID: cccc, Sub Device ID: dddd Chip is AR2312	x.x, y.y, z.z, aaaa. bbbb. cccc. dddd are the hardware versions for the different components

Get RSSI

This command gets the RSSI in dBm.

Table 5-26. RSSI Command

Command	**Parameters**
get rssi	Retrieve RSSI in dBm
Response	**Description/Parameters**
RSSI: xxx dBm	xxx is the current RSSI in dBm

5.3.5.3 Get Software Version

This command gets the WRM software version.

Table 5-27. Software Version Command

Command	**Description/Parameters**
Version	Retrieve the software version
Response	**Description/Parameters**
AP software: x.x.x.x WRM software: y.y <Time/Date of build>	x.x.x.x is the Atheros software version upon which the WRM software is based y.y is the Denso software version

5.3.6 Reboot Command

This command causes the WRM to reboot. The WRM will save the current configuration (if any changes were made via Telnet) and restore the configuration after the reset.

Table 5-28. Reboot Command

Command	**Description/Parameters**
Reboot	Reboot the WRM

5.4 WAVE Radio Module IP Interface

The WRM supports an IP packet interface to the HD. Refer to the IP specification [10] for detailed requirements. The HD and WRM use the IP interface to transfer data sent or received over the air. If the WRM is operating in WAVE mode, the WRM supports a modified version of the IP Options field in the IP header. WAVE Option types are used to support packet-by-packet control and status, and to set and get the radio configuration parameters.

5.4.1 IP Frame Format

Figure 5-6 illustrates the IPv4 frame format. All fields with the exception of the Protocol and IP Options fields must be set according to the IP specification. The Protocol field should be set to 0xff. The IP Options field optionally includes one of the WAVE options specified in section 5.4.2.

<table>
<tr><th>00</th><th>01</th><th>02</th><th>03</th><th>04</th><th>05</th><th>06</th><th>07</th><th>08</th><th>09</th><th>10</th><th>11</th><th>12</th><th>13</th><th>14</th><th>15</th><th>16</th><th>17</th><th>18</th><th>19</th><th>20</th><th>21</th><th>22</th><th>23</th><th>24</th><th>25</th><th>26</th><th>27</th><th>28</th><th>29</th><th>30</th><th>31</th></tr>
<tr><td colspan="4">Version</td><td colspan="4">IHL</td><td colspan="8">Type of Service</td><td colspan="16">Total Length</td></tr>
<tr><td colspan="16">Identification</td><td colspan="3">Flags</td><td colspan="13">Fragment Offset</td></tr>
<tr><td colspan="8">Time-To-Live</td><td colspan="8">Protocol</td><td colspan="16">Header Checksum</td></tr>
<tr><td colspan="32">Source IP</td></tr>
<tr><td colspan="32">Destination IP</td></tr>
<tr><td colspan="32">IP Options</td></tr>
<tr><td colspan="32">Payload</td></tr>
</table>

Figure 5-6. IPv4 Frame

5.4.2 WAVE Options

5.4.2.1 WAVE Tx Option

The WAVE Tx Option enables the HD to specify the radio configuration to be used for transmitting the packet, and to set the destination MAC address. This radio configuration will remain valid until a new configuration command is received or until the WRM is rebooted (this command does not save the configuration into non-volatile memory). Figure 5-7 illustrates the format of the WAVE Tx Option. Table 5-27 through Table 5-42 provide detailed field definitions.

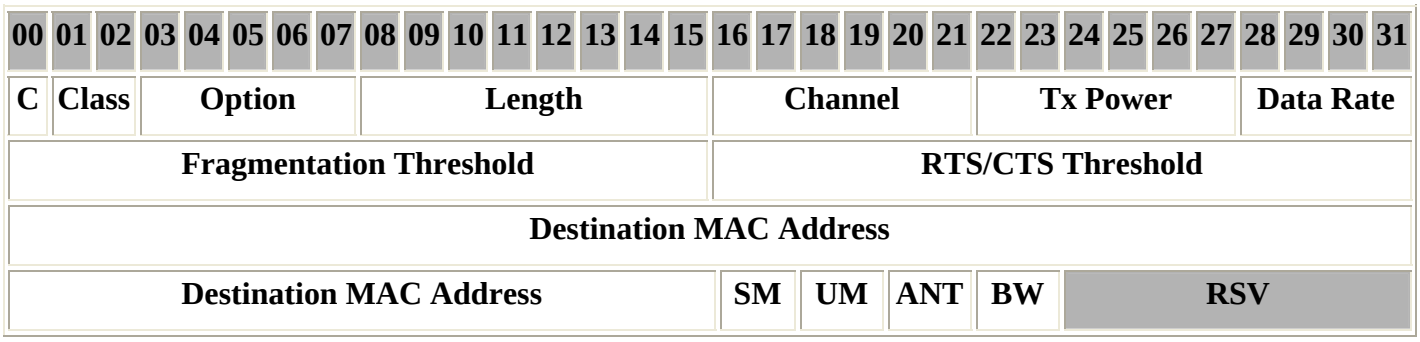


Figure 5-7. WAVE Tx Option Format

Table 5-27. Copy (C) Flag Field Definition

Bits (00)	Description
0	Indicates option field is not to be copied into all IP Packet fragments.
1	Indicates option is to be copied into all IP Packet fragments.

Table 5-28. Class Field Definition

Bits (01-02)	Description
00-01	RESERVED.
10	Set this field to debugging and measurement.
11	RESERVED.

Table 5-29. Option Field Definition

Bits (03-07)	Description
11001	Set this field to 25.

Table 5-30 Length Field Definition

Bits (08-15)	Description
00010000	Set this field to 16 (option length in octets).

Table 5-31. WAVE Channel Field Definition

Bits (16-21)	Channel Number	Channel Frequency (MHz)
000000	172	5860
000001	174	5870
000010	175	5875
000011	176	5880
000100	178	5890
000101	180	5900
000110	181	5905
000111	182	5910
001000	184	5920

Table 5-32. 802.11a Channel Field Definition

Bits (16-21)	Channel Number	Channel Frequency (MHz)
001001	RESERVED	
001010	RESERVED	
001011	RESERVED	
001100	RESERVED	
001101	52	5260
001110	56	5280
001111	60	5300
010000	64	5320
010001	149	5745
010010	153	5765
010011	157	5785
010100	161	5805
010101-111111	RESERVED	

Table 5-33. Tx Power Field Definition

Bits (22-27)	Description
111111	Set the transmit power to the maximum level
xxxxxx	Set the transmit power to xxxxxx dBm.

Table 5-34. Data Rate Field Definition

Bits (28-31)	20 MHz Channel Data Rates (Mbps)	10 MHz Channel Data Rates (Mbps)
0000	RESERVED	
0001	6	3
0010	9	4.5
0011	12	6
0100	18	9
0101	24	12
0110	36	18
0111	48	24
1000	54	27
1001-1111	RESERVED	

Table 5-35. Fragmentation Threshold Field Definition

Bits (0-15)	Description
xxxxxx	Set fragmentation threshold where xxxxxx is the length in bytes. This setting does not affect the current WRM functionality, but is implemented for future use.

Table 5-36. RTS/CTS Threshold Field Definition

Bits (16-31)	Description
xxxxxx	Set the RTS/CTS threshold where xxxxxx is the length in bytes.

Table 5-37. Destination MAC Address Field Definition

Bits (00-31, 00-15)	Description
LSB to MSB 00-31, 00-15	Set destination MAC address.

Table 5-38. Service Mode (SM) Field Definition

Bits (16-17)	Description
00	Set WRM mode to public safety operation.
01	Set WRM mode to private service operation.
10-11	RESERVED

Table 5-39. Unit Mode (UM) Field Definition

Bits (18-19)	Description
00	Set WRM to OBU mode.
01	Set WRM to RSU mode.
10-11	RESERVED

Table 5-40. Antenna (ANT) Field Definition

Bits (20-21)	Description
00	Transmit and receive on antenna 1.
01	Transmit and receive on antenna 2.
10	Transmit on antenna 1, enable receive diversity.
11	RESERVED

Table 5-41. Bandwidth (BW) Field Definition

Bits (22-23)	Description
00	Set 802.11a channel bandwidth to 10 MHz.
01	Set 802.11a channel bandwidth to 20 MHz.
10-11	RESERVED

Table 5-42. Reserved (RSV) Field Definition

Bits (24-31)	Description
00	RESERVED

5.4.2.2 WAVE Rx Option

The WAVE Rx Option enables the WRM to send the RSSI, receive antenna, and the received MAC header to the HD. Figure 5-8 illustrates the format of the WAVE Rx Option. The Copy and Class fields must be set as described for the WAVE Tx Option. Table 5-43 through Table 5-47 provide detailed field definitions for the remaining fields.

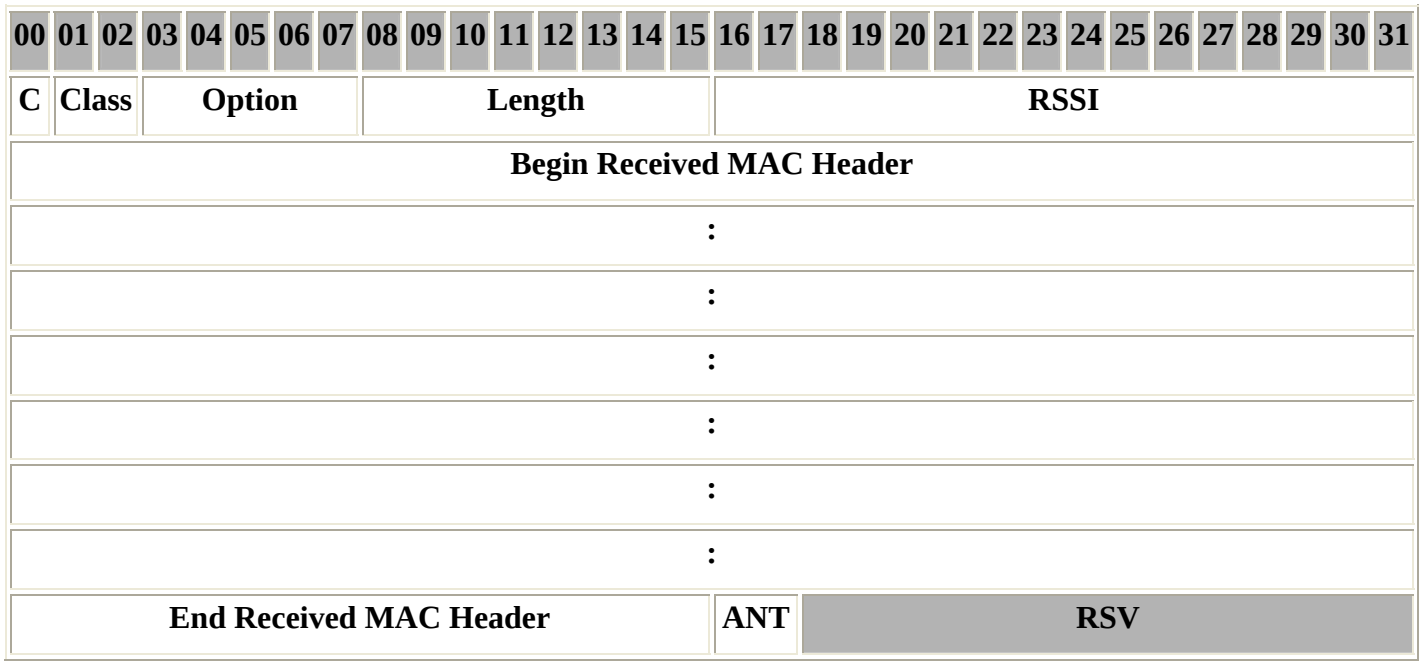


Figure 5-8. WAVE RX Option Format

Table 5-43. Option Field Definition

Bits (03-07)	Description
11010	Set this field to 26.

Table 5-44. Length Field Description

Bits (08-15)	Description
00100100	Set this field to 36 (option length in octets).

Table 5-45. RSSI Field Definition

Bits (16-31)	Description
xxxxxxx	xxxxxxxx is the received packet RSSI in dBm (negative number in 2's complement representation).

Table 5-46. Received MAC Header Field Definition

Bits (00-31, 00-15)	Description
LSB to MSB 00-31, 00-15	Set to Received MAC Header (30 octets). Refer to Section 7 in IEEE 802.11 [3].

Table 5-47. Antenna (ANT) Field Definition

Bits (16-17)	Description
00	Frame was received on Antenna 1.
01	Frame was received on Antenna 2.
10-11	RESERVED

5.4.2.3 WRM Default Configuration Option

The WAVE Default Configuration Option enables the HD to set the radio configuration to the default values specified in Table 5-4. This command causes the WRM to save the default settings into non-volatile memory. Figure 5-9 illustrates the format of the WRM Default Configuration Option. The Copy and Class must be set as described for the WAVE Tx Option. Table 5-48 through Table 5-49 provide detailed field definitions of the Option and Length fields.

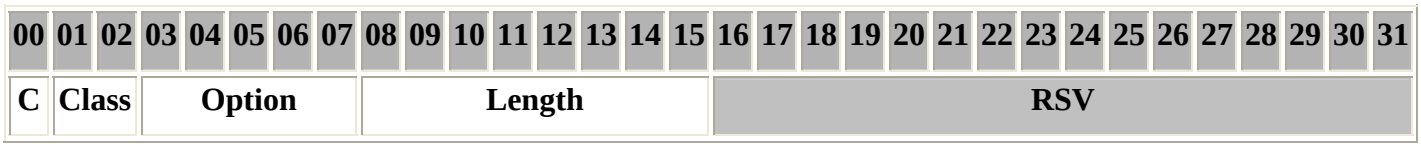


Figure 5-9. WRM Default Configuration Option Format

Table 5-48. Option Field Definition

Bits (03-07)	Description
11011	Set this field to 27.

Table 5-49. Length Field Definition

Bits (08-15)	Description
00000100	Set this field to 4 (option length in octets).

5.4.2.4 WRM Configuration Request Option

The WRM Configuration Request Option enables the HD to retrieve the WRM current radio configuration. Upon receiving the Configuration Request Option, the WRM returns the current WAVE configuration to the HD by sending a WRM Configuration Option in an IP frame (see Section 5.4.2.5). Figure 5-10 illustrates the format of the WRM Configuration Request Option. The Copy and Class must be set as described for the WAVE Tx Option. Table 5-50 through Table 5-51 provide detailed field definitions of the Option and Length fields.

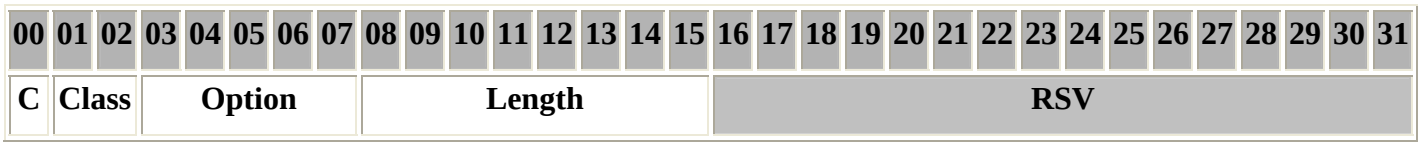


Figure 5-10. WRM Configuration Request Option Format

Table 5-50. Option Field Definition

Bits (03-07)	Description
11100	Set this field to 28.

Table 5-51. Length Field Definition

Bits (08-15)	Description
00000100	Set this field to 4 (option length in octets).

5.4.2.5 WRM Configuration Option

The WRM Configuration Option is sent from the HD to the WRM to configure the radio with specified parameters and also sent from the WRM to the HD in response to a WRM Configuration Request. The radio configuration will remain valid until a new configuration command is received or until the WRM is rebooted (this command does not save the configuration into non-volatile memory). Figure 5-11 illustrates the format of the WRM Configuration Option. The Copy and Class must be set as described for the WAVE Tx Option. Table 5-31 through Table 5-41 provides detailed field definitions for the fields common with the Tx Option [Please note that the bit position of the parameters is different from the WAVE Tx Option but the field definitions remain the same]. Table 5-52 through Table 5-56 provide detailed field definitions for the fields unique to this message.

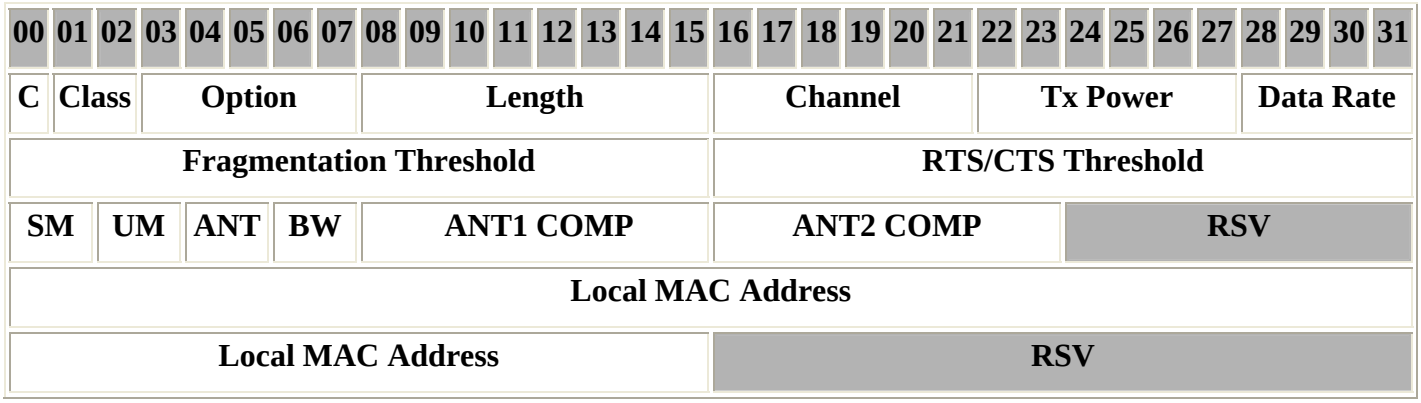


Figure 5-11. WRM Configuration Option Format

Table 5-52. Option Field Definition

Bits (03-07)	Description
11101	Set this field to 29.

Table 5-53. Length Field Definition

Bits (08-15)	Description
00010100	Set this field to 20 (option length in octets).

Table 5-54. Antenna 1 Compensation Factor Field

Bits (08-15)	Description
xxxxxxxx	xxxxxxxx is the antenna 1 compensation factor in dB (positive/negative numbers are in 2's complement representation).

Table 5-55. Antenna 2 Compensation Factor Field

Bits (16-23)	Description
xxxxxxxx	xxxxxxxx is the antenna 2 compensation factor in dB (positive/negative numbers are in 2's complement representation).

Table 5-56. Local MAC Address Field Definition Field

Bits (00-31, 00-15)	Description
LSB to MSB 00-31, 00-15	Contains the local WRM's MAC address. This field is only valid when sent from the WRM to the HD. It is unused when sent from the HD to WRM.

6 ACCEPTANCE TESTING

This chapter provides the Acceptance Test Plan (ATP) and test results for the WAVE Radio Module delivered in accordance with the VSC Project: Preliminary Requirements for Second Generation WAVE Radio Module [Section 1.2].

6.1 Scope

This WAVE Radio Module (WRM) ATP defines the tests Denso conducted to verify WRM compliance with the WAVE Radio Module Interface Specification (Chapter 5) and the software requirements of the WAVE Radio Module Functional Specification (Chapter 3). This test plan is intended to globally verify the software build which is delivered with each WRM, not to verify operation of each delivered unit. A separate set of tests was executed to verify selected functions of each delivered WRM.

As a separate task, Denso conducted tests on a limited number of units to verify whether the WRM hardware (purchased from Atheros) meets the RF performance requirements of the Functional Specification (which references ASTM E2213-03 [1]). Denso documented any areas of non-compliance in the Functional Specification.

6.2 Test Configurations

This section describes how to connect a host device to a WRM. It also describes the test setups and initialization procedures required by the tests specified in subsequent chapters.

6.2.1 WAVE Radio Module Network Connection

Set up each Host Device (HD) and WRM as shown in Figure 6-1. Each HD and WRM must have a unique IP address. Configure the HD Internet Protocol (IP) address to 192.168.001.1xx, where xx is the unit number assigned by Denso. Configure each HD with a Subnet Mask of 255.255.255.000.

6.2.2 Test Setups

For all test setups, each HD is connected to its corresponding WRM using an Ethernet crossover cable. Each HD has the API Tester and Ethereal software installed. Ethereal is a software network analyzer that may be downloaded at no charge from www.ethereal.com. The test procedures use Ethereal to verify the contents of the IP packets exchanged between the HD and the WRM. The WRM is powered using a wall power supply. See Figure 6-1. For figures illustrating subsequent test setups, the crossover cable is not labeled and the API Tester, Ethereal, and the power supply are not shown for simplicity. Unless otherwise specified, 5 dBi dipole antennas are used for both antenna 1 and antenna 2.

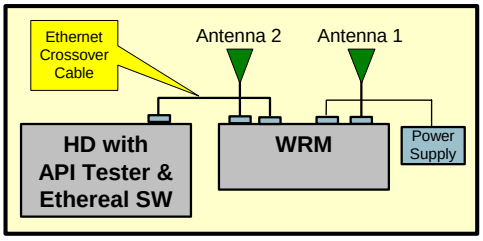


Figure 6-1. Single WRM Test Setup

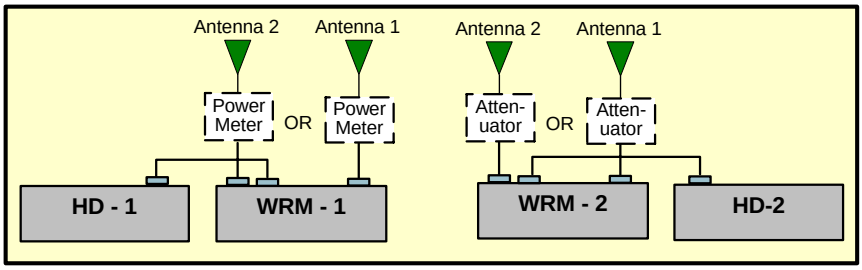


Figure 6-2. WRMs with Power Meter and Attenuator Test Setup

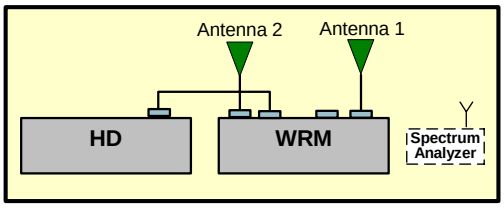


Figure 6-3. WRM with Spectrum Analyzer Test Setup

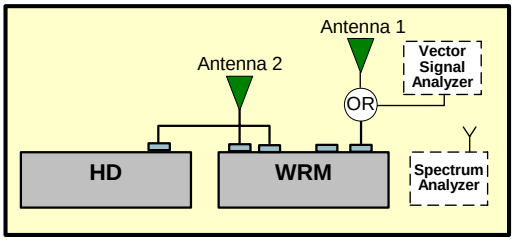


Figure 6-4. WRM with Spectrum Analyzer and Vector Signal Analyzer Test Setup

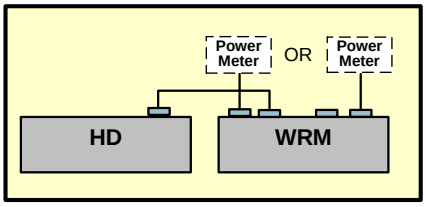


Figure 6-5. WRM with Power Meter Test Setup

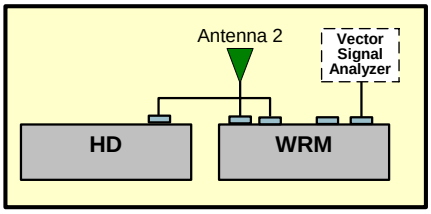


Figure 6-6. WRM with Vector Signal Analyzer Test Setup

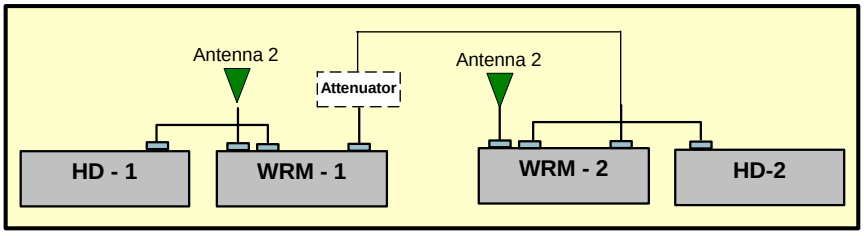


Figure 6-7. WRMs with Cable Connection

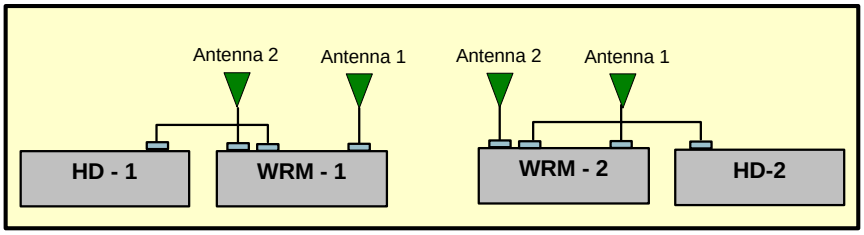


Figure 6-8. Dual WRMs

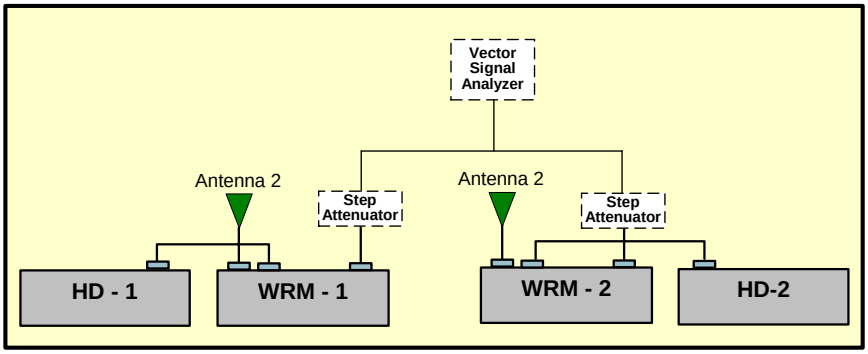


Figure 6-9. WRMs with Step Attenuators and Vector Signal Analyzer Test Setup

6.2.3 Initialization Procedures

This section defines the procedures that are used to configure the hardware and software to a known state prior to starting a test. The tests in subsequent chapters refer to these procedures when required.

6.2.3.1 Telnet Initialization Procedure

Table 6-1. Telnet Initialization Procedure

#	Description	Test Steps	Expected Results
1.	Initialize HD.	1. If it is not already running, launch the API Tester application. 2. Select the API Tester Telnet display. 3. If it is not already running, launch the Ethereal application.	The HD displays the API Tester GUI for Telnet commands/responses and the Ethereal GUI.
2.	Initialize WRM.	1. Use the API Tester to send the *set WAVEdefault* Telnet command.	API Tester displays response: *WAVEdefault.* The WRM reboots after receiving the command.

6.2.3.2 IP Initialization Procedure

Table 6-2. IP Initialization Procedure

#	Description	Test Steps	Expected Results
1.	Initialize HD.	1. If it is not already running, launch the API Tester application. 2. Select the API Tester IP display. 3. If it is not already running, launch the Ethereal application.	The HD displays the API Tester GUI for IP commands/responses and the Ethereal GUI.
2.	Initialize WRM.	1. If the WRM is not in WAVE mode, select the API Tester Telnet display and send the *set wirelessmode WAVE* Telnet command. Return to the API Tester IP display.	If the command is sent, API Tester displays WRM response: *Wireless Mode: WAVE*. The WRM reboots after receiving the command.
		2. Use the API Tester to configure the WRM to the WAVE default configuration.	The WRM reboots after receiving the command.
		3. Use the API Tester to get the current WRM configuration.	API Tester displays the current WRM configuration. The parameter values match Table 6-3.

Table 6-3. WAVE Default Parameters

Parameter	Default Value
Wireless Mode	WAVE
Unit Mode	OBU
Service Mode	Public Safety
Antenna	Best
Antenna1 Compensation	0 dB
Antenna2 Compensation	0 dB
Bandwidth *[used for 802.11a channels only]*	20 MHz
Channel	5890 MHz (IEEE 178) *[Note: Channel 178 bandwidth is 10MHz.]*
Data Rate	6 Mbps
Fragmentation Threshold	2346 bytes
Request to Send/Clear to Send (RTS/CTS) Threshold	2346 bytes
Transmit Power	20 dBm (at SMA antenna connector)

6.2.4 Software Builds

Record the WRM software version and the API Tester software version.

Table 6-4. WRM and API Tester Software Versions

WRM Software Version	API Tester Software Version	WRM Unit Number	Tests
VSCC_WRM_V0.1	VSCC API TESTER V0.1	11	6.3.3.5 (Fastchannel)
VSCC_WRM_V0.2	VSCC API TESTER V0.1	13 (WRM 1), 11 (WRM 2), 4 (WRM 3), 8 (WRM , 4 (WRM 3), 8 (WRM 4), 5 (WRM 5), 9 (WRM 6)	All other tests
VSCC_WRM_V0.2	VSCC API TESTER V0.2	13	6.3.3.4 (Bandwidth)
VSCC_WRM_V0.2	VSCC API TESTER V0.2	4	6.4.2 (MAC Address)

6.3 WRM Interface Specification Tests

This section specifies the tests to verify the WRM Interface Specification requirements. The tests get and set WRM parameters using Telnet commands and IP frames with WAVE options. The tests also verify the WRM supports transmitting and receiving IP frames with and without packet-by-packet (PBP) control and status. Refer to Section 3 of the WRM Interface Specification (Chapter 5) for the Telnet requirements and Section 4 for the IP requirements.

The subsections below define the following types of tests:

1. Telnet Tests: The Telnet tests use the API Tester to send “get” and “set” commands and display the WRM response. For set commands, the tests also verify the WRM modifies its configuration to the specified parameter values. The API Tester sends packets (i.e., IP frames with a data payload) without PBP control to the WRM for transmission, and test equipment measurements verify the configuration.
2. IP Configuration Tests: The IP Configuration Tests use the API tester to send IP frames with the WRM Configuration Option (WCO) to set the WRM configuration. The API tester gets the WRM configuration by sending an IP frame with the WRM Configuration Request Option (WCRO). The WRM responds with an IP frame with the WCO and the API tester displays the contents. The tests use Ethereal to verify the WCO and WCRO fields.

   The tests also verify the WRM modifies its configuration to the specified parameter values. The API Tester sends packets without PBP control to the

WRM for transmission, and test equipment measurements verify the configuration.

3. IP Packet-by-Packet Tests: The IP PBP Tests verify both PBP control and PBP status. For PBP control verification, the tests use the API tester to send IP frames with the WAVE Tx Option (WTXO) and a data payload to the WRM for transmission. The tests use Ethereal to verify the WTXO fields. Test equipment measurements verify the WRM configuration complies with the values specified by the WTXO.

   For PBP status verification, the test setup consists of two WRMs and their associated HDs. One WRM transmits packets with PBP control. When the second WRM receives a packet with a WTXO, it modifies the IP header by deleting the WTXO and adding the WAVE Rx Option (WRXO) before sending the packet to the HD. The tests use Ethereal to verify the WRXO fields, and also confirm the field values on the API tester display. Test equipment measurements verify the WRXO values are consistent with the receive environment.

For all of the WAVE options, the first test using the option verifies the fields with fixed values (e.g., option number, option length). Subsequent tests do not repeat this verification.

The API Tester uses all of the IP API function calls and Telnet API function calls to support the ATP. Table 6-65 and Table 6-6 describe when the calls are executed.

Table 6-5. IP API Function Calls

IP API Function Calls	When Executed
`init_WAVE_comm ()`	Executed during API Tester initialization.
`term_WAVE_comm ()`	Executed during API Tester exit.
`set_WRM_WAVEdefault ()`	Executed during 6.3.1.2 WAVEdefault IP Configuration Test.
`set_WRM_configuration ()`	Executed during all IP Configuration Tests where the WCO option is sent by the HD to the WRM.
`get_WRM_configuration ()`	Executed during all IP Configuration Tests where the WCO option is sent by the WRM to the HD.
`send_WAVE_tx_pkt ()`	Executed during all IP Configuration Tests and IP PBP Tests where packets are broadcast with PBP control.
`send_WAVE_tx_pkt_wo_config ()`	Executed during all Telnet, IP Configuration, and IP PBP Tests where packets are broadcast without PBP control.
`check_WAVE_rx_pkt ()`	Executed during all tests where packets are received by the API Tester.
`receive_WAVE_rx_pkt ()`	Executed during all tests where packets are received by the API Tester.

Table 6-6. Telnet API Function Calls

Telnet API Function Calls	When Executed
`init_telnet_comm ()`	Executed during API Tester initialization
`term_telnet_comm ()`	Executed during API Tester exit
`set_telnet_cmd ()`	Executed once each time the API Tester executes a *set* Telnet command, where the *set* command requires a parameter.
`send_telnet_cmd ()`	Executed once each time the API Tester executes a *set* Telnet command, where the *set* command does not require a parameter.
`get_telnet_cmd ()`	Executed each time the API Tester sends a *get* Telnet command to the WRM.
`get_telnet_rsp ()`	Executed after each *get* Telnet command to retrieve the parameter requested by the API Tester.
`check_telnet_rsp ()`	Executed after each *get* Telnet command to check if the WRM has responded to the request posted by the API Tester.

6.3.1 WAVE Default Command

Verify the WRM sets the WAVE parameters to the default values. This command is used to initialize the WRM to a known state at the beginning of all other tests. This command is not available with PBP control.

6.3.1.1 WAVEdefault Telnet Test

Table 6-7. WAVEdefault Telnet Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization	1. Use the test setup shown in Figure 6-1. Single WRM Test Setup. 2. Execute Telnet initialization procedure in Section 6.2.3.1.	WRM reboots.	WRM reboots.
1.	Verify default parameters	1. Use API Tester to send *get config* command and verify WRM response.	API Tester displays configuration data including default parameter values listed in Table 6-3.	Results match table 2-3.
	Verify WRM operation for key default parameters (other parameters will be tested in subsequent tests).	2. Use the test setup shown in Figure 6-4. WRM with Spectrum Analyzer and Vector Signal Analyzer Test Setup. 3. Use the API Tester to continuously broadcast packets w/o PBP control.	N/A	N/A
		4. Use the spectrum analyzer to verify channel frequency and bandwidth.	Spectrum analyzer shows center frequency of 5890 MHz and 10 MHz BW.	Center frequency = 5890 MHz. BW = 10 MHz
		5. Use the VSA to verify data rate.	VSA shows data rate of 6 Mbps.	6 Mbps
		6. Use the API tester to stop packet broadcast.	N/A	N/A
		7. Use the test setup shown in Figure 6-5. WRM with Power Meter Test Setup, with the power meter connected to the antenna 1 SMA connector. 8. Use the API Tester to continuously broadcast packets w/o PBP control. 9. Use the power meter to measure output power. 10. Use the API Tester to stop packet broadcast.	Power meter shows output power of 20dBm +\- 1 dB.	20.0 dBm

#	Description	Test Steps	Expected Results	Actual Results
	Modify configuration.	11. Use API Tester to send the following commands and display WRM response: • *set unitmode RSU* • *set servicemode private* • *set antenna 1* • *set antenna1comp 2* • *set antenna2comp –4* • *set fastchannel 52* • *set bandwidth 10 MHz* • *set rate 12 Mbps* • *set fragmentthreshold 300* • *set rtsthreshold 400* • *set power 10*	API Tester displays WRM responses echoing new settings after each *set* command.	All Telnet set and get commands correctly set and report the parameter changes.
	Verify modified configuration	12. Use the API Tester to send the *get config* command and verify the WRM response.	API Tester displays configuration data including parameter values as set in step 10.	All parameters match the values indicated in step 10.
	Verify WRM operation for key parameters.	13. Repeat test steps 2-10.	Test equipment measurements confirm values set in step 10.	Record the results in Table 6-8
	Verify WRM response to *set WAVEdefault* command.	14. Use the API Tester to send the *set WAVEdefault* Telnet command and verify the WRM response.	API Tester displays *WAVEdefault* and WRM reboots.	WRM reboots.
	Get configuration and verify default parameters.	15. Use API Tester to send *get config* command and verify WRM response.	API Tester displays configuration data including default parameter values listed in Table 6-3.	Results match default values listed in Table.
	Verify WRM operation for key parameters.	16. Repeat test steps 2-10.	Test equipment measurements confirm values in Table 6-3.	Record the results in **Error! Reference source not found.**.

Table 6-8. WAVEdefault Telnet Test Results – Modified Parameters

Settings	Expected Results	Actual Results
Frequency (MHz)	5260	5260 MHz
Bandwidth (MHz)	10	10 MHz
Data Rate	12	12 Mbps
Antenna 1 Tx Power (dBm)	10	10.4 dBm

Table 6-9. WAVEdefault Telnet Test Results – Default Parameters

Settings	Expected Results	Actual Results
Frequency (MHz)	5890	5890 MHz
Bandwidth (MHz)	10	10 MHz
Data Rate	6	6 Mbps
Antenna 1 Tx Power (dBm)	20	20.0 dBm

6.3.1.2 WAVEdefault IP Configuration Test

Table 6-10. WAVEdefault IP Configuration Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization	1. Use the test setup shown in Figure 6-1. Single WRM Test Setup. 2. Execute IP initialization procedure in Section 0.	WRM reboots.	WRM reboots.
1.	Verify default configuration.	1. Use API Tester to get WRM configuration and verify WRM response.	API Tester displays configuration data including default parameter values listed in Table 6-3.	Results match default values listed in Table.
	Verify WRM operation for key parameters.	2. Execute Table 6-7, Test Case # 1, test steps 2-10.	Test equipment measurements confirm values in Table 6-3.	Record results in Table 6-11
	Modify configuration.	3. Use API Tester to configure the WRM with the following parameter settings: • *unitmode RSU* • *servicemode private* • *antenna 1* • *antenna1comp 2* • *antenna2comp –4* • *fastchannel 52* • *bandwidth 10* • *rate 12* • *fragmentthreshold 300* • *rtsthreshold 400* • *power 10*	N/A	N/A
	Verify modified configuration	4. Use the API Tester to get the current WRM configuration.	API Tester displays configuration data including parameter values as set in step 3.	Record results in Table 6-12

#	Description	Test Steps	Expected Results	Actual Results
	Set WRM to default settings.	5. Use the API Tester to configure the WRM to the default settings. 6. Use Ethereal to verify the fixed value WDCO fields.	API Tester sends WAVE Default Configuration Option (WDCO) with the C field (Word 1, bit 00) set to copy (1), Class field (Word 1, bits 01-02) set to debugging and measurement (10), Option field (Word 1, bits 03-07) set to 27, Length field (Word 1, bits 08-15) set to 4, and RSV field (Word 1, bits 16-31 set to 0.	DB 04 00 00 **1101 1011** **0000 0100** **0000 0000** **0000 0000**
	Get configuration and verify default parameters.	7. Use API Tester to get the WRM configuration.	API Tester displays configuration data including default parameter values listed in Table 6-3.	Results match default values listed in Table.
	Verify default configuration.	8. Execute Table 6-7, Test Case # 1, test steps 2-10.	Test equipment measurements confirm values in Table 6-3.	Record results in Table 6-13

Table 6-11. WAVEdefault IP Configuration Test Results – Initial Values

Settings	Expected Results	Actual Results
Frequency (MHz)	5890	5890 MHz
Bandwidth (MHz)	10	10 MHz
Data Rate	6	6 Mbps
Antenna 1 Tx Power (dBm)	20	19.9 dBm

Table 6-12. WAVEdefault IP Configuration Test Results - Modified Parameters

Settings	Expected Results	Actual Results
Unitmode	RSU	RSU
Servicemode	Private	Private
Antenna	1	1
Antenna 1 Compensation	2	2
Antenna 2 Compensation	-4	-4
Bandwidth	10	10
Channel	52	52 (5260 MHz)

Settings	Expected Results	Actual Results
Data Rate	12	12
Fragmentation Threshold	300	300
RTS/CTS Threshold	400	400
Tx Power	10	10

Table 6-13. WAVEdefault IP Configuration Test Results - Default Parameters

Settings	Expected Results	Actual Results
Frequency (MHz)	5890	5890 MHz
Bandwidth (MHz)	10	10 MHz
Data Rate	6	6 Mbps
Antenna 1 Tx Power (dBm)	20	20.1 dBm

6.3.2 Mode Commands

6.3.2.1 Wireless Mode

Verify the WRM response to commands to get and set the wireless mode to 802.11a [2] or WAVE. After receiving a set wireless mode command, verify the WRM begins operation in the new mode within 10 seconds after receiving a reboot command. Verification of 802.11a functionality is not within the scope of this ATP. The scope of this ATP is limited to verifying the response to the mode change requests. The complete set of tests specified in this test plan verifies WAVE functionality. This command is only available through the Telnet interface.

Test Cases:

1. Wireless Mode 802.11a
2. Wireless Mode WAVE

Table 6-14. Wireless Mode Telnet Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization.	1. Use the test setup shown in Figure 6-1. Single WRM Test Setup. 2. Execute Telnet initialization procedure in Section 6.2.3.1.	N/A	N/A
1.	Verify WRM response to *set wirelessmode 11a* command.	1. Use the API Tester to send the *set wirelessmode 11a* Telnet command and verify theWRM reboots.	API Tester sets Wireless Mode to 11a and reboots.	WRM rebooted.
	Verify WRM response to *get wirelessmode* command.	2. Use the API Tester to send the *get wirelessmode* Telnet command and verify the response. Send the command 10 seconds after the reboot command.	API Tester displays response: *Wireless Mode: 11a*.	Wireless LAN Mode: 802.11a
2.	Verify WRM response to *set wirelessmode WAVE* command.	1. Use the API Tester to send the *set wirelessmode WAVE* Telnet command and verify the WRM reboots.	API Tester sets Wireless Modeto WAVE and reboots.	WRM reboots.
	Verify WRM response to *get wirelessmode* command.	2. Use the API Tester to send the *get wirelessmode* Telnet command and verify the response. Send the command 10 seconds after the reboot command.	API Tester displays response: *Wireless Mode: WAVE*.	Wireless LAN Mode: WAVE

6.3.2.2 Service Mode

Verify the WRM response to commands to get and set the service mode to public safety or private service. This setting does not affect the current WRM functionality, but is implemented for future use.

Test Cases:

1. Service Mode Private
2. Service Mode Public Safety

Service Mode Telnet Test

Table 6-15. Service Mode Telnet Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization.	1. Use the test setup shown in Figure 6-1. Single WRM Test Setup. 2. Execute Telnet initialization procedure in Section 6.2.3.1.	N/A	N/A
1.	Verify WRM response to *set servicemode private* command.	1. Use the API Tester to send the *set servicemode private* Telnet command and verify the response.	API Tester displays response: *Service Mode: private*.	Service Mode: private
	Verify WRM response to *get servicemode* command.	2. Use the API Tester to send the *get servicemode* Telnet command and verify the response.	API Tester displays response: *Service Mode: private*.	Service Mode: private
2.	Verify WRM response to *set servicemode public* command.	1. Use the API Tester to send the *set servicemode public* Telnet command and verify the response.	API Tester displays response: *Service Mode: public*.	Service Mode: public
	Verify WRM response to *get servicemode* command.	2. Use the API Tester to send the *get servicemode* Telnet command and verify the response.	API Tester displays response: *Service Mode: public*.	Service Mode: public

Service Mode IP Configuration Test

Table 6-16. Service Mode IP Configuration Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization.	1. Use the test setup shown in Figure 6-1. Single WRM Test Setup. 2. Execute IP initialization procedure in Section 6.2.3.2.	N/A	N/A
1.	Set WRM *service mode* to *private*	1. Use the API Tester to set the WRM configuration with the s*ervice mode* field set to *private*. 2. Use Ethereal to verify the fixed value fields in the WCO sent from the API Tester to the WRM.	API Tester sends WCO with the C field (Word 1, bit 00) set to copy (1), Class field (Word 1, bits 01-02) set to debugging and measurement (10), Option field (Word 1, bits 03-07) set to 29, Length field (Word 1, bits 08-15) set to 20, and RSV fields (Word 3, bits 24-31 and Word 5, bits 16-31) set to 0.	(W1) DD 14 11 43 1101 1101 0001 0100 0001 0001 0100 0011 (W2) 09 2A 09 2A (W3) 49 00 00 00 (W4) 00 00 00 00 (W5) 00 00 00 00
		3. Use Ethereal to verify the WCO service mode field.	API Tester sends WCO with service mode field (Word 3, bits 00-01) set to private (01).	(W3) 49 00 00 00 0100 1001
	Verify WRM response to *service mode private* command.	4. Use the API Tester to get the WRM configuration and verify the response.	API Tester displays service mode as private.	Private
		5. Use Ethereal to verify the WCRO fixed value fields.	API Tester sends WCRO with the C field (Word 1, bit 00) set to copy (1), Class field (Word 1, bits 01-02) set to debugging and measurement (10), Option field (Word 1, bits 03-07) set to 28, Length field (Word 1, bits 08-15) set to 4, and RSV field (Word 1, bits 16-31) set to 0.	DC 04 00 00 1101 1100 0000 0100 0000 0000 0000 0000
		6. Use Ethereal to verify the fixed value fields in the WCO sent from the WRM to the API Tester.	WRM sends WCO with the values set as described for test steps 1-2.	(W1) DD 14 11 43 (W2) 09 2A 09 2A (W3) 49 00 00 00 (W4) DA 21 3F CF (W5) 9D 5D 00 00

#	Description	Test Steps	Expected Results	Actual Results
		7. Use Ethereal to verify the WCO service mode field.	WRM sends WCO with service mode field (Word 3, bits 00-01) set to private (01).	(W3) 49 00 00 00 0100 1001 0000 0000
2.	Set WRM s*ervice mode* to *public*	1. Use the API Tester to set the WRM configuration with the s*ervice mode* field set to *public*. 2. Use Ethereal to verify the WCO service mode field.	API Tester sends WCO with service mode field (Word 3, bits 00-01) set to public (00).	(W3) 09 00 00 00 0000 1001 0000 0000
	Verify WRM response to *service mode public* command.	3. Use the API Tester to get the WRM configuration and verify the response.	API Tester displays service mode as public.	Public
		4. Use Ethereal to verify the WCO service mode field.	WRM sends WCO with the service mode field (Word 3, bits 00-01) set to public (00).	(W3) 09 00 00 00 0000 1001 0000 0000

Service Mode IP Packet-by-Packet Test

Table 6-17. Service Mode IP Packet-by-Packet Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization.	1. Use the test setup shown in Figure 6-1. Single WRM Test Setup. 2. Execute IP initialization procedure in Section 6.2.3.2.	N/A	N/A
1.	Send packet with *service mode* set to *private*	1. Use the API Tester to set the s*ervice mode* to *private* and transmit one packet with PBP control. 2. Use Ethereal to verify the fixed value fields in the WTXO.	API Tester sends WTXO with the C field (Word 1, bit 00) set to copy (1), Class field (Word 1, bits 01-02) set to debugging and measurement (10), Option field (Word 1, bits 03-07) set to 25, Length field (Word 1, bits 08-15) set to 16, and RSV field (Word 4, bits 24-31) set to 0.	(W1) D9 10 11 43 1101 1001 0001 0000 0001 0001 0100 0011 (W2) 09 2A 09 2A (W3) FF FF FF FF (W4) FF FF 49 00 1111 1111 1111 1111 0100 1001 0000 0000
		3. Use Ethereal to verify the WTXO service mode field.	API Tester sends WTXO with service mode field (Word 4, bits 16-17) set to private (01).	(W4) FF FF 49 00 1111 1111 1111 1111 0100 1001 0000 0000
	Verify WRM configuration.	4. Use the API Tester to get the WRM configuration and verify the response.	API Tester displays service mode as private.	Private

#	Description	Test Steps	Expected Results	Actual Results
2.	Send packet with s*ervice mode* set to *public*	1. Use the API Tester to set the s*ervice mode* to *public* and transmit one packet with PBP control. 2. Use Ethereal to verify the WTXO service mode field.	API Tester sends WTXO with service mode field (Word 4, bits 16-17) set to public (00).	(W4) 00 00 00 00
	Verify WRM configuration.	3. Use the API Tester to get the WRM configuration and verify the response.	API Tester displays service mode as public.	Public

6.3.2.3 Unit Mode

Verify the WRM response to commands to get and set the unit mode to OBU or RSU. The Unit Mode setting affects the maximum output power, which is verified in Section 6.2.3.2 and the random MAC address generation, which is verified in Section 6.4.2.

Test Cases:

1. Unit Mode RSU
2. Unit Mode OBU

Unit Mode Telnet Test

Table 6-18. Unit Mode Telnet Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization.	1. Use the test setup shown in Figure 6-1. Single WRM Test Setup. 2. Execute Telnet initialization procedure in Section 6.2.3.1.	N/A	N/A
1.	Verify WRM response to *set unitmode RSU* command.	1. Use the API Tester to send the *set unitmode RSU* Telnet command and verify the response.	API Tester displays response: *Unit Mode: RSU*.	Unit Mode: RSU
	Verify WRM response to *get unitmode* command.	2. Use the API Tester to send the *get unitmode* Telnet command and verify the response.	API Tester displays response: *Unit Mode: RSU*.	Unit Mode: RSU
2.	Verify WRM response to *set unitmode OBU* command.	1. Use the API Tester to send the *set unitmode OBU* Telnet command and verify the response..	API Tester displays response: *Unit Mode: OBU*.	Unit Mode: OBU

#	Description	Test Steps	Expected Results	Actual Results
	Verify WRM response to *get unitmode* command.	2. Use the API Tester to send the *get unitmode* Telnet command and verify the response.	API Tester displays response: *Unit Mode: OBU*.	Unit Mode: OBU

Unit Mode IP Configuration Test

Table 6-19. Unit Mode IP Configuration Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization.	1. Use the test setup shown in Figure 6-1. Single WRM Test Setup. 2. Execute IP initialization procedure in Section 6.2.3.2.	N/A	N/A
1.	Set WRM *unit mode* to *RSU*	1. Use the API Tester to set the WRM configuration with the *unit mode* field set to *RSU*. 2. Use Ethereal to verify the unit mode field.	API Tester sends WCO with unit mode field (Word 3, bits 02-03) set to RSU (01).	(W3) 19 00 00 00 0001 1001 0000 0000
	Verify WRM response to *unit mode RSU* command.	3. Use the API Tester to get the WRM configuration and verify the response.	API Tester displays unit mode as RSU.	RSU
		4. Use Ethereal to verify the WCO unit mode field.	WRM sends WCO with the unit mode field (Word 3, bits 02-03) set to RSU (01).	(W3) 19 00 00 00 0001 1001 0000 0000
2.	Set WRM *unit mode* to *OBU*	1. Use the API Tester to set the WRM configuration with the *unit mode* field set to *OBU*. 2. Use Ethereal to verify the WCO unit mode field.	API Tester sends WCO with unit mode field (Word 3, bits 02-03) set to OBU (00).	(W3) 09 00 00 00 0000 1001 0000 0000
	Verify WRM response to *unit mode OBU* command.	3. Use the API Tester to get the WRM configuration and verify the response.	API Tester displays unit mode as OBU.	OBU
		4. Use Ethereal to verify the WCO unit mode field.	WRM sends WCO with the unit mode field (Word 3, bits 02-03) set to OBU (00).	(W3) 09 00 00 00 0000 1001 0000 0000

6.3.2.4 Unit Mode IP Packet-by-Packet Test

Table 6-20. Unit Mode IP Packet-by-Packet Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization.	1. Use the test setup shown in Figure 6-1. Single WRM Test Setup. 2. Execute IP initialization procedure in Section 6.2.3.2.	N/A	N/A
1.	Send packet with *unit mode* set to *RSU*.	1. Use the API Tester to set the *unit mode* to *RSU* and transmit one packet with PBP control. 2. Use Ethereal to verify the WTXO unit mode field.	API Tester sends WTXO with unit mode field (Word 4, bits 18-19) set to RSU (01).	(W4) FF FF 19 00 1111 1111 1111 1111 0001 1001 0000 0000
	Verify WRM configuration.	3. Use the API Tester to get the WRM configuration and verify the response.	API Tester displays unit mode as RSU.	RSU
2.	Send packet with *unit mode* set to *OBU*.	1. Use the API Tester to set the *unit mode* to *OBU* and transmit one packet with PBP control. 2. Use Ethereal to verify the WTXO unit mode field.	API Tester sends WTXO with unit mode field (Word 4, bits 18-19) set to OBU (00).	(W4) FF FF 09 00 1111 1111 1111 1111 0000 1001 0000 0000
	Verify WRM configuration.	3. Use the API Tester to get the WRM configuration and verify the response.	API Tester displays unit mode as OBU.	OBU

6.3.3 Parameter Commands

6.3.3.1 Antenna Configuration

Verify the WRM response to commands to get and set the antenna configuration. The WRM supports transmit and receive on a single antenna (antenna 1 or 2), and also an antenna "best" mode. In "best" mode, antenna 1 is used for transmit and receive diversity is enabled.

Test Cases:

1. Antenna 1
2. Antenna 2
3. Antenna Best

Antenna Configuration Telnet Test

Table 6-21. Antenna Configuration Telnet Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization.	1. Use the test setup shown in Figure 6-2. WRMs with Power Meter and Attenuator Test Setup, with the initial condition of no power meter or attenuator attached. 2. Execute Telnet initialization procedure in Section 6.2.3.1 on both HD/WRM setups.	N/A	N/A
1.	Verify WRM-1 and WRM-2 responses to *set antenna 1* command.	1. Use HD-1 and HD-2 API Testers to send the *set antenna 1* Telnet command and verify the responses.	API Testers display response *Antenna: 1*.	Antenna: 1 Displayed by HD-1 and HD-2.
	Verify WRM-1 and WRM-2 responses to *get antenna* command.	2. Use HD-1 and HD-2 API Testers to send the *get antenna* Telnet command and verify the response.	API Testers display response A*ntenna: 1*.	Antenna: 1 Displayed by HD-1 and HD-2
	Verify WRM–1 transmits on Antenna 1.	3. Disconnect the WRM-1 antennas and attach the power meter to the antenna 1 SMA connector. 4. Use HD-1 API Tester to continuously broadcast packets w/o PBP control. 5. Measure power at the WRM-1 antenna 1 SMA connector using the power meter.	Antenna 1 power measurement = 20 dBm +/- 1 dB.	20.1 dBm
		6. Measure power at the WRM-1 antenna 2 SMA connector using the power meter	Antenna 2 power measurement <= 0.	-6 dBm
		7. Use HD-1 API Tester to stop packet broadcast. 8. Reconnect the WRM-1 antennas.	N/A	N/A

#	Description	Test Steps	Expected Results	Actual Results
	Verify WRM-2 receives on Antenna 1.	9. Attach 50 dB attenuator between WRM-2 antenna 1 and the SMA connector to reduce the received signal strength (verifies WRM will use selected antenna even though RSSI is lower). 10. Use HD-1 API Tester to continuously broadcast packets with PBP control. 11. Use HD-2 Ethereal to verify the WRXO fixed value fields.	WRM-2 sends WRXOs with the C field (Word 1, bit 00) set to copy (1), Class field (Word 1, bits 01-02) set to debugging and measurement (10), Option field (Word 1, bits 03-07) set to 26, Length field (Word 1, bits 08-15) set to 36, and RSV field (Word 9, bits 18-31) set to 0.	(W1) DA 24 FF C3 1101 1010 0010 0100 1111 1111 1100 0011 (W9) 00 00 00 00
		12. Use HD-2 Ethereal to verify the WRXO antenna field.	WRM-2 sends WRXOs with the antenna field (Word 9, bits 16-17) set to antenna 1 (00).	(W9) 00 00 00 00
		13. Use HD-2 API Tester to verify the antenna used to receive the packets.	API tester displays the packets are being received on antenna 1.	Most packets are received on antenna 1, however a few are reported received on antenna 2.
		14. Use HD-1 API Tester to stop packet broadcast. 15. Remove the attenuator on WRM-2 antenna 1.	N/A	N/A
2.	Verify WRM-1 and WRM-2 responses to *set antenna 2* command.	1. Use HD-1 and HD-2 API Testers to send the *set antenna 2* Telnet command and verify the responses.	API Testers display response *Antenna: 2*.	Antenna: 2 Displayed by HD-1 and HD-2
	Verify WRM-1 and WRM-2 responses to *get antenna* command.	2. Use HD-1 and HD-2 API Testers to send the *get antenna* Telnet command and verify the response.	API Testers display response A*ntenna: 2*.	Antenna: 2 Displayed by HD-1 and HD-2
	Verify WRM–1 transmits on Antenna 2.	3. Disconnect the WRM-1 antennas and attach the power meter to antenna 2. 4. Use HD-1 API Tester to continuously broadcast packets w/o PBP control. 5. Measure power at the WRM-1 antenna 2 SMA connector using the power meter.	Antenna 2 power measurement = 20 dBm +/- 1 dB.	19.7 dBm
		6. Measure power at the WRM-1 antenna 1 SMA connector using the power meter.	Antenna 1 power measurement <= 0 dBm.	-8 dBm

#	Description	Test Steps	Expected Results	Actual Results
		7. Use HD-1 API Tester to stop packet broadcast. 8. Reconnect the WRM-1 antennas.	N/A	N/A.
	Verify WRM-2 receives on Antenna 2.	9. Attach 50 dB attenuator between WRM-2 antenna 2 and the SMA connector. 10. Use HD-1 API Tester to continuously broadcast packets with PBP control. 11. Use HD-2 Ethereal to verify the WRXO antenna field.	WRM-2 sends WRXOs with the antenna field (Word 9, bits 16-17) set to antenna 2 (01).	(W9) 00 00 40 00 0000 0000 0000 0000 0100 0000 0000 0000
		12. Use HD-2 API Tester to verify the antenna used to receive the packets.	API Tester displays the packets are being received on antenna 2.	Most packets are received on antenna 2, however a few are reported received on antenna 1.
		13. Use HD-1 API Tester to stop packet broadcast. 14. Remove the attenuator on antenna 2.	N/A	N/A
3.	Verify WRM-1 and WRM-2 responses to *set antenna best* command.	1. Use HD-1 and HD-2 API Testers to send the *set antenna best* Telnet command and verify the responses.	API Testers display response *Antenna: best*.	Antenna: best Displayed by HD-1 and HD-2.
	Verify WRM-1 and WRM-2 responses to *get antenna* command.	2. Use HD-1 and HD-2 API Testers to send the *get antenna* Telnet command and verify the response.	API Testers display response A*ntenna: best*.	Antenna: best Displayed by HD-1 and HD-2
	Verify WRM-1 transmits on antenna 1.	3. Repeat Test Case # 1, steps 3-8.	[Same as for Test Case # 1]	Record results in Table 6-22
	Verify WRM-2 receives on “best” antenna.	4. Attach 50 db attenuator between WRM-2 antenna 1 and its SMA connector. 5. Use HD-1 API Tester to continuously broadcast packets with PBP control. 6. Use HD-2 API Tester to verify packets are received on antenna 2. 7. Use HD-1 API Tester to stop packet broadcast.	API Tester displays packets are received on antenna 2.	All packets received on antenna 2.

#	Description	Test Steps	Expected Results	Actual Results
		8. Remove attenuator from antenna 1 and attach to WRM-2 antenna 2. 9. Use HD-1 API Tester to continuously broadcast packets with PBP control. 10. Use HD-2 API Tester to verify packets are received on antenna 1. 11. Use HD-1 API Tester to stop packet broadcast.	API Tester displays packets are received on antenna 1.	All packets received on antenna 1.

Table 6-22. Antenna Configuration *"Best"* Telnet Test Result

Antenna Configuration	Expected Results		Actual Results	
	Power Measurement		Power Measurement	
	Antenna 1	Antenna 2	Antenna 1	Antenna 2
Best	20 dBm	<= 0 dBm	20.1 dBm	-5 dBm

Antenna Configuration IP Configuration Test

Table 6-23. Antenna Configuration IP Configuration Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization	1. Use the test setup shown in Figure 6-2. WRMs with Power Meter and Attenuator Test Setup, with the initial condition of no power meter or attenuator attached. 2. Execute IP initialization procedure in Section 6.2.3.2 on both HD/WRM setups.	N/A	N/A
1.	Set WRM-1 and WRM-2 *antenna* to *1*.	1. Use the HD-1 and HD-2 API Testers to set the WRM configuration with the *Antenna* field set to *1*. 2. Use Ethereal to verify the WCO antenna field.	API Testers send WCO with antenna field (Word 3, bits 04-05) set to Antenna 1 (00).	(W3) 01 00 00 00 0000 0001 0000 0000 0000 0000 0000 0000
	Verify WRM-1 and WRM-2 response to *antenna 1* command.	3. Use the HD-1 and HD-2 API Tester to get the WRM configuration and verify the response.	API Testers display antenna configuration as Antenna 1.	Antenna 1 displayed by HD-1 and HD-2.
		4. Use Ethereal to verify the WCO antenna field.	WRMs send WCO with the antenna field (Word 3, bits 04-05) set to Antenna 1 (00).	(W3) 01 00 00 00 0000 0001 0000 0000 0000 0000 0000 0000

#	Description	Test Steps	Expected Results	Actual Results
	Verify WRM-1 transmits on Antenna 1.	5. Execute Table 6-21. Antenna Configuration Telnet Test, Test Case # 1, steps 3 through 8.	[See Telnet Test]	Ant 1 = 20.0 dBm Ant 2 = -5 dBm
	Verify WRM-2 receives on Antenna 1.	6. Execute Table 6-21. Antenna Configuration Telnet Test, Test Case # 1, steps 9 through 15.	[See Telnet Test]	(W1) DA 24 FF B3 1101 1010 0010 0100 1111 1111 1011 0011 (W9) 00 00 00 00 Most packets are received on antenna 1, however a few are reported received on antenna 2.
2.	Set WRM-1 and WRM-2 *antenna* to *2*	1. Use the HD-1 and HD-2 API Testers to set the WRM configuration with the *Antenna* field set to *2*. 2. Use Ethereal to verify the WCO antenna field.	API Testers send WCO with antenna field (Word 3, bits 04-05) set to Antenna 2 (01).	(W3) 05 00 00 00 0000 0101 0000 0000 0000 0000 0000 0000
	Verify WRM-1 and WRM-2 response to *antenna 2* command.	3. Use the HD-1 and HD-2 API Testers to get the WRM configuration and verify the response.	API Testers display antenna configuration as Antenna 2.	
		4. Use Ethereal to verify the WCO antenna field.	WRMs send WCO with the antenna field (Word 3, bits 04-05) set to Antenna 2 (01).	(W3) 05 00 00 00
	Verify WRM-1 transmits on Antenna 2.	5. Execute Table 6-21. Antenna Configuration Telnet Test, Test Case # 2, steps 3 through 8.	[See Telnet Test]	Ant 2 = 19.7 dBm Ant 1 = -7 dBm
	Verify WRM-2 receives on Antenna 2.	6. Execute Table 6-21. Antenna Configuration Telnet Test, Test Case # 2, steps 9 through 14.	[See Telnet Test]	(W9) 00 00 40 00 Most packets are received on antenna 2, however a few are reported received on antenna 1.
3.	Set WRM-1 and WRM-2 *antenna* to *best*	1. Use the HD-1 and HD-2 API Testers to set the WRM configuration with the *Antenna* field set to *best*. 2. Use Ethereal to verify the WCO antenna field.	API Testers send WCO with antenna field (Word 3, bits 04-05) set to Antenna best (10).	(W3) 09 00 00 00 0000 1001 0000 0000

#	Description	Test Steps	Expected Results	Actual Results
	Verify WRM-1 and WRM-2 response to *antenna best* command.	3. Use the HD-1 and HD-2 API Testers to get the WRM configuration and verify the response.	API Testers display antenna configuration as Antenna best.	Antenna: best Displayed by HD-1 and HD-2.
		4. Use Ethereal to verify the WCO antenna field.	WRMs send WCO with the antenna field (Word 3, bits 04-05) set to Antenna best (10).	(W3) 09 00 00 00
	Verify WRM-1 transmits on Antenna 1.	5. Execute Table 6-21. Antenna Configuration Telnet Test, Test Case # 1, steps 3 through 8.	[See Telnet Test]	Ant 1 = 20.1 dBm Ant 2 = -5 dBm
	Verify WRM-2 receives on "best" antenna.	6. Execute Table 6-21. Antenna Configuration Telnet Test, Test Case # 3, steps 4 through 11.	[See Telnet Test]	All packets received on antenna 2 with attenuator on antenna 1. All packets received on antenna 1 with attenuator on antenna 2.

Antenna Configuration IP Packet-by-Packet Test

Table 6-24. Antenna Configuration IP Packet-by-Packet Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization	1. Use the test setup shown in Figure 6-2. WRMs with Power Meter and Attenuator Test Setup, with the initial condition of no power meter or attenuator attached. 2. Execute IP initialization procedure in Section 6.2.3.2 on both HD/WRM setups.	N/A	N/A
1.	Set WRM-1 and WRM-2 *antenna* to *1* using PBP control.	1. Use the HD-1 and HD-2 API Testers to set the *antenna* to *1* and transmit one packet with PBP control 2. Use Ethereal to verify the WTXO antenna field.	API Testers send WTXO with antenna field (Word 4, bits 20-21) set to Antenna 1 (00).	(W4) FF FF 01 00 1111 1111 1111 1111 0000 0001 0000 0000
	Verify WRM-1 and WRM-2 configuration.	3. Use the HD-1 and HD-2 API Testers to get the WRM configuration.	API Testers display antenna configuration as Antenna 1.	Antenna = 1
	Verify WRM-1 transmits on Antenna 1.	4. Execute Table 6-21. Antenna Configuration Telnet Test, Test Case # 1, steps 3 through 8, except transmit packets with PBP control.	[See Telnet Test]	Record results in Table 6-25

#	Description	Test Steps	Expected Results	Actual Results
	Verify WRM-2 receives on Antenna 1.	5. Execute Table 6-21. Antenna Configuration Telnet Test, Test Case # 1, steps 9 through 15.	[See Telnet Test]	Record results in Table 6-26
2.	Set WRM-1 and WRM-2 *antenna* to *2* using PBP control.	1. Use the HD-1 and HD-2 API Testers to set the *Antenna* to *2* and transmit one packet with PBP control. 2. Use Ethereal to verify the WTXO antenna field.	API Testers sends WTXO with antenna field (Word 4, bits 20-21) set to Antenna 2 (01).	(W4) FF FF 05 00 1111 1111 1111 1111 0000 0101 0000 0000
	Verify WRM-1 and WRM-2 configuration.	3. Use the HD-1 and HD-2 API Testers to get the WRM configuration.	API Tester displays antenna configuration as Antenna 2.	Antenna = 2
	Verify WRM-1 transmits on Antenna 2.	4. Execute Table 6-21. Antenna Configuration Telnet Test, Test Case # 2, steps 3 through 8, except transmit packets with PBP control.	[See Telnet Test]	Record results in Table 6-27
	Verify WRM-2 receives on Antenna 2.	5. Execute Table 6-21. Antenna Configuration Telnet Test, Test Case # 2, steps 9 through 14.	[See Telnet Test]	Record results in Table 6-28
3.	Set WRM-1 and WRM-2 *antenna* to *best* using PBP control.	1. Use the HD-1 and HD-2 API Testers to set the *Antenna* set to *best* and transmit one packet with PBP control. 2. Use Ethereal to verify the WTXO antenna field.	API Tester sends WTXO with antenna field (Word 4, bits 20-21 set to Antenna best (10).	(W4) FF FF 09 00 1111 1111 1111 1111 0000 1001 0000 0000
	Verify WRM-1 and WRM-2 configuration.	3. Use the HD-1 and HD-2 API Testers to get the WRM configuration.	API Tester displays antenna configuration as Antenna best.	Antenna = best
	Verify WRM-1 transmits on Antenna 1.	4. Execute Table 6-21. Antenna Configuration Telnet Test, Test Case # 1, steps 3 through 8, except transmit packets with PBP control.	[See Telnet Test]	Record results in Table 6-29
	Verify WRM-2 receives on "best" antenna.	5. Execute Table 6-21. Antenna Configuration Telnet Test, Test Case # 3, steps 4 through 11.	[See Telnet Test]	Record results in Table 6-30

Table 6-25. Antenna 1 Configuration IP Packet-by-Packet Tx Test Results

	Expected Results	Actual Results
Antenna 1 Power Measured	20 dBm	20.1 dBm
Antenna 2 Power Measured	<= 0 dBm	-5.3 dBm

Table 6-26. Antenna 1 Configuration IP Packet-by-Packet Rx Test Results

	Expected Results	Actual Results
HD-2 Ethereal WRXO fixed value fields results.	WRM-2 sends WRXOs with the C field (Word 1, bit 00) set to copy (1), Class field (Word 1, bits 01-02) set to debugging and measurement (10), Option field (Word 1, bits 03-07) set to 26, Length field (Word 1, bits 08-15) set to 36, and RSV field (Word 9, bits 18-31) set to 0.	(W1) DA 24 FF B5 1101 1010 0010 0100 1111 1111 1011 0101 (W9) 00 00 00 00
HD-2 Ethereal WRXO antenna field results.	WRM-2 sends WRXOs with the antenna field (Word 9, bits 16-17) set to antenna 1 (00).	(W9) 00 00 00 00
HD-2 API Tester receive antenna results.	API tester displays the packets are being received on antenna 1.	Most packets are received on antenna 1, however a few are reported received on antenna 2.

Table 6-27. Antenna 2 Configuration IP Packet-by-Packet Tx Test Results

	Expected Results	Actual Results
Antenna 2 Power Measured	20 dBm	19.8 dBm
Antenna 1 Power Measured	<= 0 dBm	-8 dBm

Table 6-28. Antenna 2 Configuration IP Packet-by-Packet Rx Test Results

	Expected Results	Actual Results
HD-2 Ethereal WRXO fixed value fields results.	WRM-2 sends WRXOs with the C field (Word 1, bit 00) set to copy (1), Class field (Word 1, bits 01-02) set to debugging and measurement (10), Option field (Word 1, bits 03-07) set to 26, Length field (Word 1, bits 08-15) set to 36, and RSV field (Word 9, bits 18-31) set to 0.	(W9) 00 00 40 00 0000 0000 0000 0000 0100 0000 0000 0000
HD-2 Ethereal WRXO antenna field results.	WRM-2 sends WRXOs with the antenna field (Word 9, bits 16-17) set to antenna 2 (01).	(W9) 00 00 40 00
HD-2 API Tester receive antenna results.	API tester displays the packets are being received on antenna 2.	Most packets are received on antenna 2, however a few are reported received on antenna 1.

Table 6-29. Antenna Best Configuration IP Packet-by-Packet Tx Results

	Expected Results	Actual Results
Antenna 1 Power Measured	20 dBm	20.1 dBm
Antenna 2 Power Measured	<= 0 dBm	-4.8 dBm

Table 6-30. Antenna Best Configuration IP Packet-by-Packet Rx Results

	Expected Results	Actual Results
Attenuator on antenna 1	API Tester displays packets are received on antenna 2.	All packets received on antenna 2.
Attenuator on antenna 2	API Tester displays packets are received on antenna 1.	All packets received on antenna 1.

6.3.3.2 Antenna 1 Compensation Factor

Verify the WRM response to commands to set the antenna 1 power compensation factor. The compensation factor affects the maximum output power, which is verified in Section 6.3.3.7. This command is not available with PBP control.

Antenna 1 Compensation Factor Telnet Test

Table 6-31. Antenna 1 Compensation Factor Telnet Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization.	1. Use the test setup shown in Figure 6-1. Single WRM Test Setup. 2. Execute Telnet initialization procedure in Section 6.2.3.1.	N/A	N/A
1.	Verify WRM response to *set antenna1comp -10* command.	1. Use the API Tester to send the *set antenna1comp -10* Telnet command and verify the WRM response.	API Tester displays WRM response: *Antenna 1 Comp: -10.*	Antenna 1 Comp: -10 dB
	Verify WRM response to *get antenna1comp* command.	2. Use the API Tester to send the *get antenna1comp* Telnet command and verify the WRM response.	API Tester displays WRM response: *Antenna 1 Comp: -10*	Antenna 1 Comp: -10 dB
	Repeat test for other compensation values.	3. Repeat test steps 1-2 for integer values –5, 0, 10, and 19.	API Tester displays WRM response: *Antenna 1 Comp: [value]*.	Record results in Table 6-32.

Table 6-32. Antenna 1 Compensation Factor Telnet Test Results

Antenna 1 Compensation	Expected Results		Actual Results	
	***set antenna1comp* Response**	***get antanna1comp* Response**	***set antenna1comp* Response**	***get antanna1comp* Response**
-5	-5	-5	-5 dB	-5 dB
0	0	0	0 dB	0 dB
10	10	10	10 dB	10 dB
19	19	19	19 dB	19 dB

Antenna 1 Compensation Factor IP Configuration Test

Table 6-33. Antenna 1 Compensation Factor IP Configuration Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization.	1. Use the test setup shown in Figure 6-1. Single WRM Test Setup. 2. Execute IP initialization procedure in Section 6.2.3.2	N/A	N/A
1.	Set WRM *antenna 1 comp to –10.*	1. Use the API Tester to set the WRM configuration with the *antenna 1 comp* field set to *-10*. 2. Use Ethereal to verify the WCO antenna 1 comp field.	API Tester sends WCO with antenna 1 compensation field (Word 3, bits 08-15) set to -10 (xF6).	(W3) 09 F6 00 00
	Verify WRM response to *antenna 1 comp* command.	3. Use the API Tester to get the WRM configuration and verify the response.	API Tester displays antenna 1 compensation factor as –10 dB.	10 dB
		4. Use Ethereal to verify the WCO antenna 1 comp field.	WRM sends WCO with the antenna1comp field set to -10.	(W3) 09 F6 00 00
	Repeat test for other compensation values.	5. Repeat test steps 1-4 for integer values from –5, 0, 10, and 19.	WRM sends WCO with the antenna 1comp field set to the specified value. API Tester displays antenna 1 compensation factor as the specified value.	Record results in Table 6-34.

Table 6-34. Antenna 1 Compensation Factor IP Configuration Test Results

Antenna 1 Compensation	Expected Results			Actual results		
	WCO antenna 1 compensation field		API Tester antenna 1 compensation	WCO antenna 1 compensation field		API Tester antenna 1 compensation
	set	get		set	get	
-5	-5	-5	-5	(0xFB) -5	(0xFB) -5	-5 dB
0	0	0	0	(0x00) 0	(0x00) 0	0 dB
10	10	10	10	(0x0A) 10	(0x0A) 10	10 dB
19	19	19	19	(0x13) 19	(0x13) 19	19 dB

6.3.3.3 Antenna 2 Compensation Factor

Verify the WRM response to commands to set the antenna 2 power compensation factor. The compensation factor affects the maximum output power, which is verified in Section 6.3.3.7.

Test Procedure: Repeat the procedure in Section 6.3.3.2 except substitute antenna 2 for antenna 1. WCO contains antenna 2 compensation in Word 3, Bits 16-23. Record the results in Table 6-35 and Table 6-36.

Table 6-35. Antenna 2 Compensation Factor Telnet Test Results

Antenna 2 Compensation	Expected Results		Actual results	
	***set antenna2comp* Response**	***get antanna2comp* Response**	***set antenna2comp* Response**	***get antanna2comp* Response**
-10	-10	-10	-10 dB	-10 dB
-5	-5	-5	-5 dB	-5 dB
0	0	0	0 dB	0 dB
10	10	10	10 dB	10 dB
19	19	19	19 dB	19 dB

Table 6-36. Antenna 2 Compensation Factor IP Configuration Test Results

Antenna 2 Compensation	Expected Results			Actual results		
	WCO antenna 2 compensation field		API Tester antenna 2 compensation	WCO antenna 2 compensation field		API Tester antenna 2 compensation
	set	get		set	get	
-10	-10	-10	-10	(0xF6) -10	(0xF6) -10	-10 dB
-5	-5	-5	-5	(0xFB) -5	(0xFB) -5	-5 dB
0	0	0	0	(0x00) 0	(0x00) 0	0 dB
10	10	10	10	(0x0A) 10	(0x0A) 10	10 dB
19	19	19	19	(0x13) 19	(0x13) 19	19 dB

6.3.3.4 Bandwidth

Verify the WRM supports WAVE mode operation at 10 MHz and 20MHz bandwidth for 802.11a channels. Upon switching from a WAVE channel to an 802.11a channel, verify the WRM sets the bandwidth to the current bandwidth setting.

Bandwidth Telnet Test

Test Cases:

1. 10 MHz WAVE Channel -> 802.11a Channel Change (20 MHz default bandwidth)
2. 10 MHz BW Command
3. 802.11a -> 20 MHz WAVE Channel Change
4. 20 MHz WAVE Channel -> 802.11a Channel Change
5. 20 MHz BW Command

Table 6-37. Bandwidth Telnet Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization.	1. Use the test setup shown in Figure 6-3. WRM with Spectrum Analyzer Test Setup. 2. Execute Telnet initialization procedure in Section 6.2.3.1.	N/A	N/A
1.	Change channel from 10 MHz WAVE channel to 802.11a channel.	1. Use the API Tester to send the *set fastchannel 52* Telnet command.	API Tester displays response: *Radio Frequency: 5260 MHz (IEEE 52).*	Radio Frequency: 5260 MHz (IEEE 52)
	Verify WRM sets BW to current setting (20 MHz).	2. Use the API Tester to send the *get bandwidth* Telnet command and verify the response.	API Tester displays response: *Channel Bandwidth: 20 MHz.*	Channel Bandwidth: 20 MHz
		3. Use the API Tester to continuously broadcast packets w/o PBP control. 4. Verify the channel frequency and 20 MHz BW using the spectrum analyzer.	Spectrum analyzer shows center frequency of 5260 MHz and 20 MHz BW.	Center frequency = 5260 MHz. Bandwidth = 20 MHz.
		5. Use API Tester to stop packet broadcast.	N/A	N/A
2.	Verify WRM response to *set bandwidth 10* command.	1. Use the API Tester to send the *set bandwidth 10* Telnet command and verify the response.	API Tester displays response *Channel Bandwidth: 10 MHz.*	Channel Bandwidth: 10 MHz
	Verify WRM response to *get bandwidth* command.	2. Use the API Tester to send the *get bandwidth* Telnet command and verify the response.	API Tester displays response: *Channel Bandwidth: 10 MHz.*	Channel Bandwidth: 10 MHz
	Verify 10 MHz operation.	3. Use the API Tester to continuously broadcast packets w/o PBP control. 4. Verify the 10 MHz BW using the spectrum analyzer.	Spectrum analyzer shows 10 MHz BW.	Bandwidth = 10 MHz.
		5. Use the API Tester to stop packet broadcast.	N/A	N/A

3.	Change channel from 802.11a channel to 20 MHz WAVE channel.	1. Use the API Tester to send the *set fastchannel 175* Telnet command.	API Tester displays response: *Radio Frequency: 5875 MHz (IEEE 175).*	Radio Frequency: 5875 MHz (IEEE 175)
	Verify channel and 20 MHz operation.	2. Use the API Tester to continuously broadcast packets w/o PBP control. 3. Verify the channel and 20 MHz BW using the spectrum analyzer.	Spectrum analyzer shows center frequency of 5875 MHz and 20 MHz BW.	Bandwidth = 20 MHz
		4. Use the API Tester to stop packet broadcast.	N/A	N/A
4.	Change channel from 20 MHz WAVE channel to 802.11a channel.	1. Use the API Tester to send the *set fastchannel 161* Telnet command.	API Tester displays response: *Radio Frequency: 5805 MHz (IEEE 161).*	Radio Frequency 5805 MHz (IEEE 161)
	Verify WRM sets BW to current setting (10 MHz).	2. Use the API Tester to send the *get bandwidth* Telnet command and verify the response.	API Tester displays response: *Channel Bandwidth: 10 MHz.*	Channel Bandwidth: 10 MHz
		3. Use the API Tester to continuously broadcast packets w/o PBP control. 4. Verify the channel frequency and 10 MHz BW using the spectrum analyzer.	Spectrum analyzer shows center frequency of 5805 MHz and 10 MHz BW.	Bandwidth = 10 MHz
		5. Use the API Tester to stop packet broadcast.	N/A	N/A
5.	Verify WRM response to *set bandwidth 20* command.	1. Use the API Tester to send the *set bandwidth 20* Telnet command and verify the response.	API Tester displays response *Channel Bandwidth: 20 MHz.*	Channel Bandwidth: 20 MHz
	Verify WRM response to *get bandwidth* command.	2. Use the API Tester to send the *get bandwidth* Telnet command and verify the response.	API Tester displays response: *Channel Bandwidth: 20 MHz.*	Channel Bandwidth: 20 MHz
	Verify 20 MHz operation.	3. Use the API Tester to continuously broadcast packets w/o PBP control. 4. Verify the 20 MHz BW using the spectrum analyzer.	Spectrum analyzer shows 20 MHz BW.	Bandwidth = 20 MHz
		5. Use the API Tester to stop packet broadcast.	N/A	N/A

Bandwidth IP Configuration Test

Test Cases:

1. 20 MHz BW Command
2. 10 MHz BW Command

Table 6-38. Bandwidth IP Configuration Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization.	1. Use the test setup shown in Figure 6-3. WRM with Spectrum Analyzer Test Setup. 2. Execute IP initialization procedure in Section 6.2.3.2.	N/A	N/A
1.	Set WRM configuration to 802.11a channel and *20 MHz BW*.	1. Use the API Tester to set the WRM configuration to channel 52 and *20 MHz BW*. 2. Use Ethereal to verify the WCO BW field.	API sends WCO with BW field (Word 3, bits 06-07) set to 20 MHz (01)	(W3) 09 00 00 00 0000 1001 0000 0000
	Verify WRM response to *20 MHz BW* command.	3. Use the API Tester to get the WRM configuration. 4. Use Ethereal to verify the WCO BW field.	WRM sends WCO with BW field set to 20 MHz.	(W3) 09 00 00 00
		5. Use the API Tester to verify the response.	API Tester displays bandwidth as 20 MHz.	20 MHz
		6. Use the API Tester to continuously broadcast packets w/o PBP control. 7. Verify the channel frequency and 20 MHz BW using the spectrum analyzer.	Spectrum analyzer shows center frequency of 5260 MHz and 20 MHz BW.	Center frequency = 5260 MHz Bandwidth = 20 MHz
		8. Use the API Tester to stop packet broadcast.	N/A	N/A
2.	Set WRM configuration to *10 MHz BW*.	1. Use the API Tester to set the WRM configuration to *10 MHz BW*. 2. Use Ethereal to verify the WCO BW field..	API sends WCO with BW field (Word 3, bits 06-07) set to 10 MHz (00)	(W3) 08 00 00 00 0000 1000 0000 0000
	Verify WRM response to 1*0 MHz BW* command.	3. Use the API Tester to get the WRM configuration. 4. Use Ethereal to verify the WCO BW field.	WRM sends WCO with BW field (Word 3, bits 06-07) set to 10 MHz (00)	(W3) 08 00 00 00
		5. Use the API Tester to verify the response.	API Tester displays bandwidth as 10 MHz.	10 MHz

#	Description	Test Steps	Expected Results	Actual Results
		6. Use the API Tester to continuously broadcast packets w/o PBP control. 7. Verify the channel frequency and 10 MHz BW using the spectrum analyzer.	Spectrum analyzer shows center frequency of 5260 MHz and 10 MHz BW.	Center frequency = 5260 MHz Bandwidth = 10 MHz
		8. Use the API Tester to stop packet broadcast.	N/A	N/A

Bandwidth IP Packet-by-Packet Test

Test Cases:

1. 10 MHz BW Command
2. 20 MHz BW Command

Table 6-39. Bandwidth IP Packet-by-Packet Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization.	1. Use the test setup shown in Figure 6-3. WRM with Spectrum Analyzer Test Setup. 2. Execute IP initialization procedure in Section 6.2.3.2.	N/A	N/A
1.	Set WRM configuration to 802.11a channel and *10 MHz BW* using PBP control.	1. Use the API Tester to set the WRM configuration to *channel 52* and *10 MHz BW* and transmit one packet with PBP control. 2. Use Ethereal to verify the WTXO BW field.	API sends WTXO with BW field (Word 4, bits 22-23) set to 10 MHz (00)	(W4) FF FF 08 00 1111 1111 1111 1111 0000 1000 0000 0000
	Verify WRM configuration.	3. Use the API Tester to get the WRM configuration.	API Tester displays BW as 10 MHz.	10 MHz
		4. Use the API Tester to continuously broadcast packets with PBP control. 5. Verify the channel frequency and 10 MHz BW using the spectrum analyzer.	Spectrum analyzer shows center frequency of 5260 MHz and 10 MHz BW.	Center frequency = 5260 MHz Bandwidth = 10 MHz
		6. Use the API Tester to stop packet broadcast.	N/A	N/A

2.	Set WRM configuration to *20 MHz BW* using PBP control.	1. Use the API Tester to set the WRM configuration to *20 MHz BW* and transmit one packet with PBP control. 2. Use Ethereal to verify the WTXO BW field.	API sends WTXO with BW field (Word 4, bits 22-23) set to 20 MHz (01)	(W4) FF FF 09 00 1111 1111 1111 1111 0000 1001 0000 0000
	Verify WRM configuration.	3. Use the API Tester to get the WRM configuration.	API Tester displays BW as 20 MHz.	20 MHz
		4. Use the API Tester to continuously broadcast packets with PBP control. 5. Verify the 20 MHz BW using the spectrum analyzer.	Spectrum analyzer shows 20 MHz BW.	Center frequency = 5260 MHz Bandwidth = 20 MHz
		6. Use the API Tester to stop packet broadcast.	N/A	N/A

6.3.3.5 Fastchannel

Verify the WRM supports WAVE mode operation on all WAVE and 802.11a channels.

The channel setting affects the channel bandwidth, data rate, and maximum output power.

- Bandwidth -- For WAVE channels, verify the WRM sets the channel bandwidth to 10 or 20 MHz depending on the channel number.
- Data Rate -- When switching from a 20 MHz to a 10 MHz channel using a Telnet command, verify the WRM halves the previous data rate. When switching from a 10 MHz to a 20 MHz channel, verify the WRM doubles the previous data rate.
- Maximum Output Power – Section 6.3.3.7 verifies these requirements.

Fastchannel Telnet Test

Test Cases:

1. Channel Frequency and BW Verification
2. Channel Data Rate Verification

Table 6-40. Fastchannel Telnet Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization.	1. Use the test setup shown in Figure 6-4. WRM with Spectrum Analyzer and Vector Signal Analyzer Test Setup, with antenna 1 installed (i.e., VSA is not connected) 2. Execute Telnet initialization procedure in Section 6.2.3.1.	N/A	N/A
1.	Verify WRM response to *set fastchannel 172* command.	1. Use the API Tester to send the *set fastchannel 172* Telnet command and verify the response.	API Tester displays response: *Radio Frequency: 5860 MHz (IEEE 172).*	Radio Frequency: 5860 MHz (IEEE 172)
	Verify WRM response to *get fastchannel* command.	2. Use the API Tester to send the *get fastchannel* command and verify the response.	API Tester displays WRM response: *Radio Frequency: 5860 MHz (IEEE 172).*	Radio Frequency: 5860 MHz (IEEE 172)
	Verify channel frequency and BW.	3. Use the API Tester to continuously broadcast packet traffic w/o PBP control. 4. Use Spectrum Analyzer to verify WRM is transmitting on channel 172 with 10 MHz BW.	Spectrum Analyzer shows center frequency of 5860 MHz and 10 MHz BW.	Center frequency = 5860 MHz Bandwidth = 10 MHz
		5. Use API Tester to stop packet broadcast.	N/A	N/A
	Verify frequency and BW for all remaining WAVE and 802.11a channels.	6. Repeat steps 1-5 for all WAVE and 802.11a channels listed in 7. Table 6-41 and 8. Table 6-42.	The API Tester displays the correct frequency, and channel number in accordance with Table 6-41 and Table 6-42. The spectrum analyzer verifies the correct center frequency and BW.	Record results in Table 6-41 and Table 6-42.
2.	Modify setup to support data rate verification.	1. Disconnect antenna 1 and connect to VSA to antenna 1 SMA connector.	N/A	N/A
	Verify data rate.	2. Use the API Tester to send the *set fastchannel 172* Telnet command and verify the response.	API Tester displays response: *Radio Frequency: 5860 MHz (IEEE 172).*	Radio Frequency: 5860 MHz (IEEE 172)
		3. Use the API Tester to send the *get rate* Telnet command and verify the response.	API Tester displays *Data Rate: 6.*	Data Rate: 6

#	Description	Test Steps	Expected Results	Actual Results
		4. Use the API Tester to continuously broadcast packet traffic w/o PBP control. 5. Use VSA to verify data rate. 6. Use API Tester to stop packet broadcast.	VSA shows data rate is 6 Mbps.	6 Mbps
	Verify data rate for all remaining WAVE and 802.11a channels.	7. Repeat steps 2-6 for all WAVE and 802.11a channels listed in Table 6-43 and Table 6-44.	For 10 MHz channels, the data rate is 6 (Mbps). For 20 MHz channels, the data rate is 12 (Mbps).	Record results in Table 6-43 and Table 6-44.

Table 6-41. WAVE Channel Frequency and BW Telnet Test Results

Test Channels	Expected Results			Actual Results					
	Frequency (MHz)	Channel Number	BW (MHz)	*set fastchannel*		*get fastchannel*		Spectrum analyzer	
				Freq	Channel	Freq	Channel	Freq	BW
172	5860	172	10	5960	172	5860	172	5860	10
174	5870	174	10	5870	174	5870	174	5870	10
175	5875	175	20	5875	175	5875	175	5875	20
176	5880	176	10	5880	176	5880	176	5880	10
178	5890	178	10	5890	178	5890	178	5890	10
180	5900	180	10	5900	180	5900	180	5900	10
181	5905	181	20	5905	181	5905	181	5905	20
182	5910	182	10	5910	182	5910	182	5910	10
184	5920	184	10	5920	184	5920	184	5920	10

Table 6-42. 802.11a Channel Frequency and BW Telnet Test Results

Test Channels	Expected Results			Actual Results					
	Frequency (MHz)	Channel Number	BW (MHz)	*set fastchannel*		*get fastchannel*		Spectrum analyzer	
				Freq	Channel	Freq	Channel	Freq	BW
52	5260	52	20	5260	52	5269	52	5260	20
56	5280	56	20	5280	56	5280	56	5280	20
60	5300	60	20	5300	60	5300	60	5300	20
64	5320	64	20	5320	64	5320	64	5320	20
149	5745	149	20	5745	149	5745	149	5745	20
153	5765	153	20	5765	153	5765	153	5765	20
157	5785	157	20	5785	157	5785	157	5785	20
161	5805	161	20	5805	161	5805	161	5805	20

Table 6-43. WAVE Channel Data Rate Telnet Test Results

Test Channels	Expected Results				Actual Results			
	Channel Number	Frequency (MHz)	BW (MHz)	Data Rate	*set fastchannel*		*get rate*	VSA Data Rate
					Frequency	Channel	Data Rate	
172	172	5860	10	6	5860	172	6 Mbps	6 Mbps
174	174	5870	10	6	5870	174	6 Mbps	6 Mbps
175	175	5875	20	12	5875	175	12 Mbps	12 Mbps
176	176	5880	10	6	5880	176	6 Mbps	6 Mbps
178	178	5890	10	6	5890	178	6 Mbps	6 Mbps
180	180	5900	10	6	5900	180	6 Mbps	6 Mbps
181	181	5905	20	12	5905	181	12 Mbps	12 Mbps
182	182	5910	10	6	5910	182	6 Mbps	6 Mbps
184	184	5920	10	6	5920	184	6 Mbps	6 Mbps

Table 6-44. 802.11a Channel Data Rate Telnet Test Results

Test Channels	Expected Results				Actual Results			
	Channel Number	Frequency (MHz)	BW (MHz)	Data Rate	*set fastchannel*		*get rate*	VSA Data Rate
					Frequency	Channel	Data Rate	
52	52	5260	20	12	5260	52	12 Mbps	12 Mbps
56	56	5280	20	12	5280	56	12 Mbps	12 Mbps
60	60	5300	20	12	5300	60	12 Mbps	12 Mbps
64	64	5320	20	12	5320	64	12 Mbps	12 Mbps
149	149	5745	20	12	5745	149	12 Mbps	12 Mbps
153	153	5765	20	12	5765	153	12 Mbps	12 Mbps
157	157	5785	20	12	5785	157	12 Mbps	12 Mbps
161	161	5805	20	12	5805	161	12 Mbps	12 Mbps

Fastchannel IP Configuration Test

Test Cases:

1. Channel Frequency and BW Verification

Table 6-45. Fastchannel IP Configuration Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization.	1. Use the test setup shown in Figure 6-3. WRM with Spectrum Analyzer Test Setup. 2. Execute IP initialization procedure in Section 6.2.3.2.	N/A	N/A
1.	Set WRM *channel* to *172.*	1. Use the API Tester to set the WRM configuration with the channel of 172. 2. Use Ethereal to verify the WCO channel field.	API Tester sends WCO with channel field (Word 1, bits 16-21) set to 172 (000000)	(W1) DD 14 01 43 1101 1101 0001 0100 **0000 00**01 0100 0011
	Verify WRM response to the *channel 172* command.	3. Use the API Tester to get the WRM configuration. 4. Use Ethereal to verify the WCO channel field.	WRM sends WCO with channel field (Word 1, bits 16-21) set to 172 (000000).	(W1, Byte 3) 01 **0000 00**01
		5. Use the API Tester to verify the response.	API Tester displays Channel 172 and 10 MHz BW.	Channel = 172 Bandwidth = 10 MHz

#	Description	Test Steps	Expected Results	Actual Results
	Verify channel frequency and BW.	6. Use the API Tester to continuously broadcast packet traffic w/o PBP control. 7. Use Spectrum Analyzer to verify WRM is transmitting on channel 172 with 10 MHz BW.	Spectrum Analyzer shows center frequency of 5860 MHz and 10 MHz BW.	Center frequency 5860 MHz 10 MHz
		8. Use the API Tester to stop packet broadcast.	N/A	N/A
	Verify frequency and BW for all remaining WAVE and 802.11a channels.	9. Repeat steps 1-8 for all WAVE and 802.11a channels listed in Table 6-46 and Table 6-47.	The WCO channel field values (Word 1, bits 16-21) are in accordance with Table 6-46 and Table 6-47. The spectrum analyzer shows center frequencies and BW in accordance with Table 6-46 and Table 6-47.	Record results in Table 6-46 and Table 6-47.

Table 6-46. WAVE Channel Frequency and BW IP ConfigurationTest Results

	Expected Results				Actual Results					
					Ethereal WCO Channel Field Results		API Tester Results		Spectrum Analyzer	
Test Chan	Channel Number	Frequency (MHz)	BW (MHz)	WCO Channel Field	Set WRM Config.	Get WRM Config.	Chan	BW	Freq	BW
172	172	5860	10	000000	0x01	0x01	5860	N/A	5860	10
174	174	5870	10	000001	0x05	0x05	5870	N/A	5870	10
175	175	5875	20	000010	0x09	0x09	5875	N/A	5875	20
176	176	5880	10	000011	0x0D	0x0D	5880	N/A	5880	10
178	178	5890	10	000100	0x11	0x11	5890	N/A	5890	10
180	180	5900	10	000101	0x15	0x15	5900	N/A	5900	10
181	181	5905	20	000110	0x19	0x19	5905	N/A	5905	20
182	182	5910	10	000111	0x1D	0x1D	5910	N/A	5910	10
184	184	5920	10	001000	0x21	0x21	5920	N/A	5920	10

Table 6-47. 802.11a Channel Frequency and BW IP Configuration Test Results

Test Chan	Expected Results				Actual Results					
					Ethereal WCO Channel Field Results		API Tester Results		Spectrum Analyzer	
	Channel Number	Frequency (MHz)	BW (MHz)	WCO Channel Field	Set WRM Config.	Get WRM Config.	Chan	BW	Freq	BW
52	52	5260	20	001101	0x35	0x35	52	20	5260	20
56	56	5280	20	001110	0x39	0x39	56	20	5280	20
60	60	5300	20	001111	0x3D	0x3D	60	20	5300	20
64	64	5320	20	010000	0x41	0x41	64	20	5320	20
149	149	5745	20	010001	0x45	0x45	149	20	5745	20
153	153	5765	20	010010	0x49	0x49	153	20	5765	20
157	157	5785	20	010011	0x4D	0x4D	157	20	5786	20
161	161	5805	20	010100	0x51	0x51	161	20	5805	20

Fastchannel IP Packet-by-Packet Test

Test Cases:

1. Channel Frequency and BW Verification

Table 6-48. Fastchannel IP Packet-by-Packet Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization.	1. Use the test setup shown in Figure 6-3. WRM with Spectrum Analyzer Test Setup. 2. Execute IP initialization procedure in Section 6.2.3.2.	N/A	N/A
1.	Set WRM *channel* to *172* using PBP control.	1. Use the API Tester to set the WRM configuration to *channel 172* and transmit one packet with PBP control. 2. Use Ethereal to verify the WTXO channel field.	API Tester sends WTXO with channel field (Word 1, bits 16-21) set to 172 (000000).	(W1, Byte 3) 01 0000 0001
	Verify WRM configuration.	3. Use the API Tester to get the WRM configuration.	API Tester displays channel 172.	172
		4. Use the API Tester to continuously broadcast packets with PBP control. 5. Verify the channel frequency and 10 MHz BW using the spectrum analyzer.	Spectrum analyzer shows center frequency of 5860 MHz and 10 MHz BW.	Center Frequency = 5860 MHz Bandwidth = 10 MHz

#	Description	Test Steps	Expected Results	Actual Results
		6. Use the API Tester to stop packet broadcast.	N/A	N/A
	Verify frequency and BW for all remaining WAVE and 802.11a channels.	7. Repeat steps 1-6 for all WAVE and 802.11a channels listed in Table 6-49 and Table 6-50.	The WTXO channel field values (Word 1, bits 16-21) are in accordance with Table 6-49 and Table 6-50. The spectrum analyzer shows center frequencies and BW in accordance with Table 6-49 and Table 6-50.	Record results in Table 6-49 and Table 6-50.

Table 6-49. WAVE Channel Frequency and BW IP Packet-by-Packet Test Results

Test Chan	Expected Results				Actual Results			
	Channel Number	Frequency (MHz)	BW (MHz)	WTXO Channel Field	Ethereal WTXO Channel Field Results	API Tester Results	Spectrum Analyzer Results	
						Channel	Freq	BW
172	172	5860	10	000000	0x01	172	5860	10
174	174	5870	10	000001	0x05	174	5870	10
175	175	5875	20	000010	0x09	175	5875	20
176	176	5880	10	000011	0x0D	176	5880	10
178	178	5890	10	000100	0x11	178	5890	10
180	180	5900	10	000101	0x15	180	5900	10
181	181	5905	20	000110	0x19	181	5905	20
182	182	5910	10	000111	0x1D	182	5910	10
184	184	5920	10	001000	0x21	184	5920	10

Table 6-50. 802.11a Channel Frequency and BW IP Packet-by-Packet Test Results

Test Chan	Expected Results				Actual Results			
	Channel Number	Frequency (MHz)	BW (MHz)	WTXO Channel Field	Ethereal WTXO Channel Field Results	API Tester Results	Spectrum Analyzer Results	
						Channel	Freq	BW
52	52	5260	20	001101	0x35	52	5260	20
56	56	5280	20	001110	0x39	56	5280	20
60	60	5300	20	001111	0x3D	60	5300	20
64	64	5320	20	010000	0x41	64	5320	20
149	149	5745	20	010001	0x45	149	5745	20
153	153	5765	20	010010	0x49	153	5765	20
157	157	5785	20	010011	0x4D	157	5785	20
161	161	5805	20	010100	0x51	161	5805	20

6.3.3.6 Fragment Threshold

Verify the WRM supports setting the MAC packet fragmentation length threshold. The valid range of values is 256 to 2346 bytes.

Test Cases:

1. No fragmentation.
2. One packet fragmented into two packets.
3. One packet fragmented into three packets.

Fragment Threshold Telnet Test

Table 6-51. Fragment Threshold Telnet Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization	1. Use test setup shown in Figure 6-6. WRM with Vector Signal Analyzer Test Setup. 2. Execute the Telnet initialization procedure in Section 6.2.3.1.	N/A	N/A
1.	Verify WRM does not fragment when MAC	1. Use the API Tester to send the *get fragmentthreshold* Telnet command.	API Tester displays response: *Fragment Threshold: 2346*	

#	Description	Test Steps	Expected Results	Actual Results
	packet size is less than fragment threshold.	2. Use the API Tester to enter a destination MAC address and transmit a single 1400 byte data packet w/o PBP control. 3. Use the VSA to display the MAC payload size.	VSA displays MAC payload size of 1456 bytes. (This MAC payload size accounts for 28 bytes of MAC header, 20 bytes of IP header, 8 bytes of layer 2 header, and 1400 bytes of data payload.)	
2.	Verify WRM fragments one packet into two packets when MAC packet size exceeds fragment threshold.	1. Use the API Tester to send the *set fragmentthreshold 1000* Telnet command.	API Tester displays response: *Fragment Threshold: 1000*	
		2. Use the API Tester to transmit a single 1400 byte data packet w/o PBP control. 3. Use the VSA to display the MAC payload size.	VSA displays two MAC packets, one with payload size of 1056 and another with payload size of 456 bytes.	
3.	Verify WRM fragments one packet into three packets when MAC packet size exceeds fragment threshold.	1. Use the API Tester to send the *set fragmentthreshold 500* Telnet command.	API Tester displays response: *Fragment Threshold: 500*	
		2. Use the API Tester to transmit a single 1400 byte data packet w/o PBP control. 3. Use the VSA to display the MAC payload size.	VSA displays three MAC packets, two with payload size of 556and a third with payload size of 456 bytes.	

Fragment Threshold IP Configuration Test

Table 6-52. Fragment Threshold IP Configuration Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization	1. Use test setup shown in Figure 6-6. WRM with Vector Signal Analyzer Test Setup. 2. Execute the IP initialization procedure in Section 6.2.3.2.	N/A	N/A
1.	Verify WRM does not fragment when MAC packet size is less than fragment threshold.	1. Use the API Tester to get the WRM configuration and verify the *Fragment Threshold.*	API Tester displays Fragment Threshold of 2346 bytes.	
		2. Use the API Tester to enter a destination MAC address and transmit a single 1400 byte data packet w/o PBP control. 3. Use the VSA to display the MAC payload size.	VSA displays MAC payload size of 1456 bytes.	

#	Description	Test Steps	Expected Results	Actual Results
2.	Verify WRM fragments one packet into two packets when MAC packet size exceeds fragment threshold.	1. Use the API Tester to set the *Fragment Threshold* to *1000* bytes. 2. Use Ethereal to verify the WCO Fragment Threshold field.	API Tester sends WCO with Fragmentation Threshold field (word 2, bits 0-15) set to 1000 (x03E8).	
		3. Use the API Tester to transmit a single 1400 byte data packet w/o PBP control. 4. Use the VSA to display the MAC payload size.	VSA displays two MAC packets, one with payload size of 1056 and another with payload size of 456bytes.	
3.	Verify WRM fragments one packet into three packets when MAC packet size exceeds fragment threshold.	1. Use the API Tester to set the *Fragment Threshold* to *500* bytes. 2. Use Ethereal to verify the WCO Fragmentation Threshold field.	API Tester sends WCO with Fragmentation Threshold field (word 2, bits 0-15) set to 500 (x01F4).	
		3. Use the API Tester to transmit a single 1400 byte data packet w/o PBP control. 4. Use the VSA to display the MAC payload size.	VSA displays three MAC packets, two with payload size of 556and a third with payload size of 456 bytes.	

Fragment Threshold IP Packet-by-Packet Test

Table 6-53. Fragment Threshold IP Packet-by-Packet Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization	1. Use test setup shown in Figure 6-6. WRM with Vector Signal Analyzer Test Setup. 2. Execute the IP initialization procedure in Section 6.2.3.2.	N/A	N/A
1.	Verify WRM does not fragment when MAC packet size is less than fragment threshold.	1. Use the API Tester to get the WRM configuration and verify the *Fragment Threshold.*	API Tester displays Fragment Threshold of 2346 bytes.	
		2. Use the API Tester to enter a destination MAC address and transmit a single 1400 byte data packet with PBP control. 3. Use the VSA to display the MAC payload size.	VSA displays MAC payload size of 1472 bytes. (This MAC payload size accounts for 28 bytes of MAC header, 20 bytes of IP header, 8 bytes of layer 2 header, 16 bytes of IP options, and 1400 bytes of data payload.)	

#	Description	Test Steps	Expected Results	Actual Results
2.	Verify WRM fragments one packet into two packets when MAC packet size exceeds fragment threshold.	1. Use the API Tester to set the *Fragment Threshold* to *1000* bytes and transmit a single 1400 byte data packet with PBP control. 2. Use Ethereal to verify the WTXO Fragment Threshold field.	API Tester sends WTXO with Fragmentation Threshold field (word 2, bits 0-15) set to 1000 (x03E8).	
		3. Use the VSA to display the MAC payload size.	VSA displays two MAC packets, one with payload size of 1072and another with payload size of 472 bytes.	
3.	Verify WRM fragments one packet into three packets when MAC packet size exceeds fragment threshold.	1. Use the API Tester to set the *Fragment Threshold* to *500* bytes. 2. Use Ethereal to verify the WTXO Fragment Threshold field.	API Tester sends WTXO with Fragmentation Threshold field (word 2, bits 0-15) set to 500 (x01F4).	
		3. Use the API Tester to transmit a single 1400 byte data packet w/o PBP control. 4. Use the VSA to display the MAC payload size.	VSA displays three MAC packets, two with payload size of 572 and a third with payload size of 472 bytes.	

6.3.3.7 Power

Power Level

Verify the WRM supports transmitting at power levels up to nominally 20 dBm, or higher if available. The valid range is 0 to 20 dBm in 1 dB increments or full for maximum power. (Full power may or may not be higher than 20 dBm.)

Test Cases:

1. Antenna 1 Output Power at SMA Connector
2. Antenna 2 Output Power at SMA Connector

Power Level Telnet Test

Table 6-54. Power Level Telnet Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization	1. Use test setup shown in Figure 6-5. WRM with Power Meter Test Setup, with power meter connected to antenna 1 SMA connector. 2. Execute the Telnet initialization procedure in Section 6.2.3.1.	N/A	N/A
1.	Verify WRM response to *set power 0* command.	1. Use API Tester to send the *set power 0* Telnet command and verify the response. .	API Tester displays response: *Transmit Power: 0*.	Transmit Power: 0dBm
	Verify WRM response to *get power* command.	2. Use API Tester to send the *get power* Telnet command and verify the response.	API Tester displays response: *Transmit Power: 0*.	Transmit Power: 0dBm
	Verify output power level.	3. Use API Tester to continuously broadcast packet traffic w/o PBP control. 4. Measure the transmit power at the antenna 1 SMA connector using the power meter.	Power meter displays antenna 1 power measurement = 0 dBm +/- 1 dB.	0 dBm
		5. Use API Tester to stop packet broadcast.	N/A	N/A
	Verify 1-20 dBm in 1 dB increments, and full.	6. Repeat steps 1-5 for all power settings from 1 to 20 dBm in 1 dB increments, and “full”.	API Tester displays response: Transmit Power: xx, where xx is the specified level. Power meter displays specified power within +\- 1 dB. For “full”, the power is 20 dBm +2/-1 dB.	Record results in Table 6-55.
2.	Verify output power levels on antenna 2.	1. Use the API Tester to send the *set antenna 2* Telnet command and verify the response.	API Tester displays response: *Antenna: 2*.	Antenna: 2
		2. Connect power meter to the antenna 2 SMA connector. 3. Repeat Test Case # 1 for all power settings from 0 to 20 dBm in 1 dB increments, and “full”.	API Tester displays response: Transmit Power: xx, where xx is the specified level. Power meter displays specified power within +/- 1 dB. For “full”, the power is 20 dBm +2/-1 dB.	Record results in Table 6-56.

Table 6-55. Antenna 1 Output Power Level Telnet Test Results

Power Level (dBm)	Expected Results			Actual Results		
	set power **Response**	***get power*** **Response**	**Power Meter Reading**	***set power*** **Response**	***get power*** **Response**	**Power Meter Reading**
1	1	1	1	1 dBm	1 dBm	-0.15 dBm
2	2	2	2	2 dBm	2 dBm	2.5 dBm
3	3	3	3	3 dBm	3 dBm	3.9 dBm
4	4	4	4	4 dBm	4 dBm	4.5 dBm
5	5	5	5	5 dBm	5 dBm	5.9 dBm
6	6	6	6	6 dBm	6 dBm	6.8 dBm
7	7	7	7	7 dBm	7 dBm	8.2 dBm
8	8	8	8	8 dBm	8 dBm	9.0 dBm
9	9	9	9	9 dBm	9 dBm	11.0 dBm
10	10	10	10	10 dBm	10 dBm	11.9 dBm
11	11	11	11	11 dBm	11 dBm	12.5 dBm
12	12	12	12	12 dBm	12 dBm	13.7 dBm
13	13	13	13	13 dBm	13 dBm	14.6 dBm
14	14	14	14	14 dBm	14 dBm	15.5 dBm
15	15	15	15	15 dBm	15 dBm	16.5 dBm
16	16	16	16	16 dBm	16 dBm	17.4 dBm
17	17	17	17	17 dBm	17 dBm	18.3 dBm
18	18	18	18	18 dBm	18 dBm	19.0 dBm
19	19	19	19	19 dBm	19 dBm	19.5 dBm
20	20	20	20	20 dBm	20 dBm	20.1 dBm
full	full	full	20	full	full	20.5 dBm

Table 6-56. Antenna 2 Output Power Level Telnet Test Results

Power Level (dBm)	Expected Results			Actual Results		
	set power **Response**	***get power*** **Response**	**Power Meter Reading**	***set power*** **Response**	***get power*** **Response**	**Power Meter Reading**
0	0	0	0	0 dBm	0 dBm	-0.7 dBm
1	1	1	1	1 dBm	1 dBm	-0.7 dBm
2	2	2	2	2 dBm	2 dBm	2.0 dBm
3	3	3	3	3 dBm	3 dBm	3.3 dBm
4	4	4	4	4 dBm	4 dBm	3.9 dBm
5	5	5	5	5 dBm	5 dBm	5.3 dBm
6	6	6	6	6 dBm	6 dBm	6.4 dBm
7	7	7	7	7 dBm	7 dBm	7.5 dBm
8	8	8	8	8 dBm	8 dBm	8.5 dBm
9	9	9	9	9 dBm	9 dBm	10.4 dBm
10	10	10	10	10 dBm	10 dBm	11.4 dBm
11	11	11	11	11 dBm	11 dBm	12.0 dBm
12	12	12	12	12 dBm	12 dBm	13.0 dBm
13	13	13	13	13 dBm	13 dBm	14.3 dBm
14	14	14	14	14 dBm	14 dBm	15.1 dBm
15	15	15	15	15 dBm	15 dBm	16.1 dBm
16	16	16	16	16 dBm	16 dBm	17.2 dBm
17	17	17	17	17 dBm	17 dBm	17.9 dBm
18	18	18	18	18 dBm	18 dBm	18.7 dBm
19	19	19	19	19 dBm	19 dBm	19.2 dBm
20	20	20	20	20 dBm	20 dBm	19.8 dBm
full	full	full	20	full	full	20.1 dBm

Power Level IP Configuration Test

Table 6-57. Power Level IP Configuration Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization	1. Use test setup shown in Figure 6-5. WRM with Power Meter Test Setup, with the power meter connected to the antenna 1 SMA connector. 2. Execute the IP initialization procedure in Section 6.2.3.2.	N/A	N/A
1.	Set WRM *power level* to *0* dBm.	1. Use the API Tester to set the WRM configuration with the *power level* at *0 dBm*. 2. Use Ethereal to verify the WCO Tx power field.	API Tester sends WCO with Tx power field (Word 1, bits 22-27) set to 0 (000000).	(W1) DD 14 1**0 0**3 1101 1101 0001 0100 0001 00**00 0000** 0011
	Verify WRM response to the *power level 0* command.	3. Use the API Tester to get the WRM configuration. 4. Use Ethereal to verify the WCO Tx power field.	WRM sends WCO with Tx power field (Word 1, bits 22-27) set to 0.	(W1, Bytes 3-4) 10 03
		5. Use the API Tester to verify the response.	API Tester displays *Power Level 0 dBm*.	0 dBm
	Verify output power level.	6. Use the API Tester to continuously broadcast packet traffic w/o PBP control. 7. Use the power meter to measure the power level.	Power meter displays antenna 1 power measurement = 0 dBm +/- 1 dB.	-0.1 dBm
		8. Use the API Tester to stop packet broadcast.	N/A	N/A
	Verify 1-20 dBm in 1 dB increments, and full.	9. Repeat steps 1-8 for all power settings from 1 to 20 dBm in 1 dB increments, and “full”.	WCO Tx Power field contains the specified power level or all 1s for “full”. API Tester displays *Power Level: xx*, where xx is the specified level. Power meter displays specified power within +/- 1 dB. For “full”, the power is 20 dBm +2/-1 dB.	Record results in Table 6-58.
2.	Verify output power levels on antenna 2.	1. Use the API Tester to set the WRM configuration with the antenna set to 2. 2. Use the API Tester to get the WRM configuration.	API Tester displays *Antenna 2.*	Antenna = 2

#	Description	Test Steps	Expected Results	Actual Results
		3. Connect power meter to the antenna 2 SMA connector. 4. Repeat Test Case # 1 for all power settings from 0 to 20 dBm in 1 dB increments, and "full".	WCO Tx power field contains the specified power level or all 1s for "full". API Tester displays *Power Level: xx*, where xx is the specified level. Power meter displays specified power within +/- 1 dB. For "full", the power is 20 dBm +2/-1 dB.	Record results in Table 6-59.

Table 6-58. Antenna 1 Output Power Level IP Configuration Test Results

Power Level (dBm)	Expected Results				Actual Results			
	WCO Tx Power field		API Tester Power Level	Power Meter Reading	WCO Tx Power field (Word 1, bits 22-27)		API Tester Power Level	Power Meter Reading
	set	get			set	get		
1	000001	000001	1	1	01	01	1 dBm	0.0 dBm
2	000010	000010	2	2	02	02	2 dBm	2.6 dBm
3	000011	000011	3	3	03	03	3 dBm	4.0 dBm
4	000100	000100	4	4	04	04	4 dBm	4.5 dBm
5	000101	000101	5	5	05	05	5 dBm	5.8 dBm
6	000110	000110	6	6	06	06	6 dBm	6.8 dBm
7	000111	000111	7	7	07	07	7 dBm	8.3 dBm
8	001000	001000	8	8	08	08	8 dBm	9.1 dBm
9	001001	001001	9	9	09	09	9 dBm	11.0 dBm
10	001010	001010	10	10	0A	0A	10 dBm	12.3
11	001011	001011	11	11	0B	0B	11 dBm	12.6 dBm
12	001100	001100	12	12	0C	0C	12 dBm	13.8 dBm
13	001101	001101	13	13	0D	0D	13 dBm	14.7 dBm
14	001110	001110	14	14	0E	0E	14 dBm	15.6 dBm
15	001111	001111	15	15	0F	0F	15 dBm	16.6 dBm
16	010000	010000	16	16	10	10	16 dBm	17.3 dBm
17	010001	010001	17	17	11	11	17 dBm	18.5 dBm
18	010010	010010	18	18	12	12	18 dBm	19.0 dBm

Power Level (dBm)	Expected Results				Actual Results			
	WCO Tx Power field		API Tester Power Level	Power Meter Reading	WCO Tx Power field (Word 1, bits 22-27)		API Tester Power Level	Power Meter Reading
	set	get			set	get		
19	010011	010011	19	19	13	13	19 dBm	19.5 dBm
20	010100	010100	20	20	14	14	20 dBm	20.1 dBm
full	111111	111111	full	20	3F	3F	full	20.5 dBm

Table 6-59. Antenna 2 Output Power Level IP Configuration Test Results

Power Level (dBm)	Expected Results				Actual Results			
	WCO Tx Power field		API Tester Power Level	Power Meter Reading	WCO Tx Power field (Word 1, bits 22-27)		API Tester Power Level	Power Meter Reading
	set	get			set	get		
0	000000	000000	0	0	00	00	0 dBm	-0.7 dBm
1	000001	000001	1	1	01	01	1 dBm	-0.7 dBm
2	000010	000010	2	2	02	02	2 dBm	1.9 dBm
3	000011	000011	3	3	03	03	3 dBm	3.3 dBm
4	000100	000100	4	4	04	04	4 dBm	4.0 dBm
5	000101	000101	5	5	05	05	5 dBm	5.3 dBm
6	000110	000110	6	6	06	06	6 dBm	6.5 dBm
7	000111	000111	7	7	07	07	7 dBm	7.7 dBm
8	001000	001000	8	8	08	08	8 dBm	8.5 dBm
9	001001	001001	9	9	09	09	9 dBm	10.4 dBm
10	001010	001010	10	10	0A	0A	10 dBm	11.3 dBm
11	001011	001011	11	11	0B	0B	11 dBm	12.0 dBm
12	001100	001100	12	12	0C	0C	12 dBm	13.0 dBm
13	001101	001101	13	13	0D	0D	13 dBm	14.3 dBm
14	001110	001110	14	14	0E	0E	14 dBm	15.1 dBm
15	001111	001111	15	15	0F	0F	15 dBm	16.1 dBm
16	010000	010000	16	16	10	10	16 dBm	17.1 dBm
17	010001	010001	17	17	11	11	17 dBm	18.0 dBm
18	010010	010010	18	18	12	12	18 dBm	18.6 dBm
19	010011	010011	19	19	13	13	19 dBm	19.2 dBm

Power Level (dBm)	Expected Results				Actual Results			
	WCO Tx Power field		API Tester Power Level	Power Meter Reading	WCO Tx Power field (Word 1, bits 22-27)		API Tester Power Level	Power Meter Reading
	set	get			set	get		
20	010100	010100	20	20	14	14	20 dBm	19.8 dBm
full	111111	111111	full	20	3F	3F	full	20.1 dBm

Power Level IP Packet-by-Packet Test

Table 6-60. Power Level IP Packet-by-Packet Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization	1. Use test setup shown in Figure 6-5. WRM with Power Meter Test Setup, with the power meter connected to the antenna 1 SMA connector. 2. Execute the IP initialization procedure in Section 6.2.3.2.	N/A	N/A
1.	Set WRM *power level* to *0* dBm using PBP control.	1. Use the API Tester to set the WRM configuration *power level* to *0 dBm* and transmit one packet with PBP control. 2. Use Ethereal to verify the WTXO Tx power field.	API Tester sends WTXO with Tx power field (Word 1, bits 22-27) set to 0 (000000).	(W1) D9 10 1**0 0**3 1101 1001 0001 0000 0001 00**00 0000** 0011
	Verify WRM configuration.	3. Use the API Tester to get the WRM configuration.	API Tester displays *Power Level 0 dBm*.	0 dBm
	Verify output power level.	4. Use the API Tester to continuously broadcast packet traffic with PBP control. 5. Use the power meter to measure the power level.	Power meter displays antenna 1 power measurement = 0 dBm +/- 1 dB.	-0.7 dBm
		6. Use API Tester to stop packet broadcast	N/A	N/A
	Verify 1-20 dBm in 1 dB increments, and full.	7. Repeat steps 1- 6 for all power settings from 1 to 20 dBm in 1 dB increments, and "full".	WTXO field contains the specified power level or all 1s for "full". API Tester displays *Power Level: xx*, where xx is the specified level. Power meter displays specified power within +/- 1 dB. For "full", the power is 20 dBm +2/-1 dB.	Record results in Table 6-61.

#	Description	Test Steps	Expected Results	Actual Results
2.	Verify output power levels on antenna 2.	1. Use the API Tester to set the WRM configuration with the antenna set to 2.	N/A	Antenna = 2
		2. Connect power meter to the antenna 2 SMA connector. 3. Repeat Test Case # 1 for all power settings from 0 to 20 dBm in 1 dB increments, and "full".	WTXO field contains the specified power level or all 1s for "full". API Tester displays *Power Level: xx*, where xx is the specified level. Power meter displays specified power within +/- 1 dB. For "full", the power is 20 dBm +2/-1 dB.	Record results in Table 6-62.

Table 6-61. Antenna 1 Output Power Level IP Packet-by-Packet Test Results

Power Level (dBm)	Expected Results			Actual Results		
	WTXO Tx Power field	API Tester Power Level	Power Meter Reading	WTXO Tx Power field (W1, bits 22-27)	API Tester Power Level	Power Meter Reading
1	000001	1	1	0x01	1 dBm	0.0 dBm
2	000010	2	2	0x02	2 dBm	2.7 dBm
3	000011	3	3	0x03	3 dBm	4.0 dBm
4	000100	4	4	0x04	4 dBm	4.8 dBm
5	000101	5	5	0x05	5 dBm	6.1 dBm
6	000110	6	6	0x06	6 dBm	6.9 dBm
7	000111	7	7	0x07	7 dBm	8.1 dBm
8	001000	8	8	0x08	8 dBm	9.1 dBm
9	001001	9	9	0x09	9 dBm	10.9 dBm
10	001010	10	10	0x0A	10 dBm	11.7 dBm
11	001011	11	11	0x0B	11 dBm	12.6 dBm
12	001100	12	12	0x0C	12 dBm	13.7 dBm
13	001101	13	13	0x0D	13 dBm	14.6 dBm
14	001110	14	14	0x0E	14 dBm	15.4 dBm
15	001111	15	15	0x0F	15 dBm	16.4 dBm
16	010000	16	16	0x10	16 dBm	17.2 dBm

Power Level (dBm)	Expected Results			Actual Results		
	WTXO Tx Power field	API Tester Power Level	Power Meter Reading	WTXO Tx Power field (W1, bits 22-27)	API Tester Power Level	Power Meter Reading
17	010001	17	17	0x11	17 dBm	18.4 dBm
18	010010	18	18	0x12	18 dBm	18.9 dBm
19	010011	19	19	0x13	19 dBm	19.4 dBm
20	010100	20	20	0x14	20 dBm	20.0 dBm
full	111111	full	20	0x3F	full	20.5 dBm

Table 6-62. Antenna 2 Output Power Level IP Packet-by-Packet Test Results

Power Level (dBm)	Expected Results			Actual Results		
	WTXO Tx Power field	API Tester Power Level	Power Meter Reading	WTXO Tx Power field (W1, bits 22-27)	API Tester Power Level	Power Meter Reading
0	000000	0	0	0x00	0 dBm	-0.7 dBm
1	000001	1	1	0x01	1 dBm	-0.6 dBm
2	000010	2	2	0x02	2 dBm	2.1 dBm
3	000011	3	3	0x03	3 dBm	3.4 dBm
4	000100	4	4	0x04	4 dBm	3.9 dBm
5	000101	5	5	0x05	5 dBm	5.5 dBm
6	000110	6	6	0x06	6 dBm	6.2 dBm
7	000111	7	7	0x07	7 dBm	7.4 dBm
8	001000	8	8	0x08	8 dBm	8.4 dBm
9	001001	9	9	0x09	9 dBm	10.4 dBm
10	001010	10	10	0x0A	10 dBm	11.4 dBm
11	001011	11	11	0x0B	11 dBm	12.4 dBm
12	001100	12	12	0x0C	12 dBm	13.3 dBm
13	001101	13	13	0x0D	13 dBm	14.1 dBm
14	001110	14	14	0x0E	14 dBm	15.1 dBm
15	001111	15	15	0x0F	15 dBm	16.1 dBm
16	010000	16	16	0x10	16 dBm	17.0 dBm
17	010001	17	17	0x11	17 dBm	17.8 dBm

Power Level (dBm)	Expected Results			Actual Results		
	WTXO Tx Power field	API Tester Power Level	Power Meter Reading	WTXO Tx Power field (W1, bits 22-27)	API Tester Power Level	Power Meter Reading
18	010010	18	18	0x12	18 dBm	18.5 dBm
19	010011	19	19	0x13	19 dBm	19.1 dBm
20	010100	20	20	0x14	20 dBm	19.7 dBm
full	111111	full	20	0x3F	full	20.1 dBm

WAVE Channel Power Limiting

Verify the WRM limits the transmit power at the SMA connector for WAVE channels so the maximum allowable level at the antenna input will not be exceeded. The maximum allowable antenna input power is a function of unit mode and channel. The maximum allowable power at the SMA connector is a function of the maximum allowable antenna input power and the antenna compensation factor.

Test Cases:

1. Power Limiting at Antenna 1 SMA Connector
2. Power Limiting at Antenna 2 SMA Connector

RSU Power Limiting Telnet Test

Table 6-63. RSU Power Limiting Telnet Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization	1. Use the test setup shown in Figure 6-5. WRM with Power Meter Test Setup, with the power meter connected to the antenna 1 SMA connector. 2. Execute Telnet initialization procedure in Section 6.2.3.1.	N/A	N/A
1.	Set the WRM unit mode to RSU.	1. Use the API Tester to send the *set unitmode RSU* Telnet command and verify the response.	API Tester displays response: *Unit Mode: RSU.*	Unit Mode: RSU

#	Description	Test Steps	Expected Results	Actual Results
	Set the channel, antenna compensation factor, and power setting.	2. Use the API Tester to send the *set channel 172* Telnet command. 3. Use the API Tester to send the *set antenna1comp 0* Telnet command. 4. Use the API Tester to send the *set power 10* Telnet command. 5. Use the API Tester to verify the response for the above commands.	API Tester displays response: *Radio Frequency: 5860 MHz (IEEE 172).* API Tester displays response: *Antenna1comp: 0.* API Tester displays response: *Transmit Power: 10.*	Radio Frequency: 5860 MHz (IEEE 172) Antenna 1 Comp: 0 dB Transmit Power: 10 dBm
	Verify the output power level at the SMA antenna connector.	6. Use the API Tester to continuously broadcast packets w/o PBP control. 7. Measure the transmit power at the antenna 1 SMA connector using the power meter.	Power meter displays antenna 1 power = 10 dBm +/- 1 dB.	12.1 dBm
		8. Use the API Tester to stop packet broadcast.	N/A	N/A
	Verify the output power levels for other parameter settings.	9. Repeat steps 2-8 using the combinations of channel, antenna compensation factor, and power levels listed in Table 6-64.	See Table 6-64.	Record results in Table 6-64.
2.	Set the antenna to 2.	1. Use the API Tester to send the *set antenna 2* Telnet command and verify the response. 2. Connect the power meter to the antenna 2 SMA connector.	API Tester display response: *Antenna: 2.*	Antenna: 2
	Verify the output power levels.	3. Execute Test Case # 1, steps 2-9 using the combinations of channel, antenna compensation factor, and power levels listed in Table 6-65. Measure output power at the antenna 2 SMA connector.	See Table 6-65.	Record results in Table 6-65.

Table 6-64. RSU Power Limiting at Antenna 1 Telnet Test Results

Channel	Ant. Input Limit (dBm)	Antenna Comp.	Power	Expected Results (dBm)	Actual Results (dBm)				
					Channel 172	Channel 174	Channel 176	Channel 178	Channel 184
172, 174, 176, 178,	28.8	0	10	10	12.1	12.1	12.0	12.1	12.0
			15	15	16.7	16.4	16.3	16.4	16.5
			20	20	20.5	20.2	20.1	20.1	20.2
		10	10	10	12.1	12.1	11.7	11.8	11.8

Channel	Ant. Input Limit (dBm)	Antenna Comp.	Power	Expected Results (dBm)	Actual Results (dBm)				
					Channel 172	**Channel 174**	**Channel 176**	**Channel 178**	**Channel 184**
184			15	15	16.7	16.4	16.3	16.4	16.5
			20	19	19.8	19.6	19.4	19.5	19.6
		19	10	10	12.1	11.9	11.8	11.8	11.8
			15	10	12.1	11.8	11.7	11.7	11.7
			20	10	12.1	11.8	11.7	11.8	11.7
					Channel 175	**Channel 180**	**Channel 181**	**Channel 182**	
175, 180, 181, 182	10.0	-10	0	0	-0.1	0.1	-0.1	0.0	
			10	10	11.2	12.4	11.5	12.4	
			20	20	19.5	20.4	19.7	20.5	
		-5	0	0	-0.3	0.0	0.1	0.0	
			10	10	11.3	12.1	11.4	12.1	
			20	15	15.9	16.6	16.2	16.8	
		0	0	0	-0.2	0.0	0.0	0.0	
			10	10	11.2	12.1	11.3	12.1	
			20	10	11.2	12.1	11.6	12.1	

Table 6-65. RSU Power Limiting at Antenna 2 Telnet Test Results

Channel	Ant. Input Limit (dBm)	Antenna Comp.	Power	Expected Results (dBm)	Actual Results (dBm)				
					Channel 172	**Channel 174**	**Channel 176**	**Channel 178**	**Channel 184**
172, 174, 176, 178, 184	28.8	0	10	10	11.3	10.7	11.3	11.3	10.5
			15	15	16.1	15.5	16.0	16.1	15.2
			20	20	19.8	19.2	19.8	19.9	19.1
		10	10	10	11.2	10.8	11.2	11.3	10.5
			15	15	16.0	15.5	16.0	16.0	15.2
			20	19	19.1	18.7	19.2	19.2	18.4
		19	10	10	11.3	10.7	11.3	11.3	10.5
			15	10	11.3	10.7	11.3	11.3	10.5
			20	10	11.3	10.7	11.3	11.3	10.5
					Channel 175	**Channel 180**	**Channel 181**	**Channel 182**	
175, 180, 181, 182	10.0	-10	0	0	-1.0	-0.9	-1.2	-1.2	
			10	10	10.4	11.1	10.0	10.6	
			20	20	18.9	19.3	18.4	19.0	
		-5	0	0	-0.9	-0.8	-1.4	-1.2	
			10	10	10.4	11.0	10.2	10.5	
			20	15	15.0	15.7	14.8	15.4	
		0	0	0	-1.0	-1.0	-1.3	-1.3	
			10	10	10.5	11.0	10.0	10.5	
			20	10	10.5	11.0	10.0	10.6	

RSU Power Limiting IP Configuration Test

Table 6-66. RSU Power Limiting IP Configuration Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization	1. Use the test setup shown in Figure 6-5. WRM with Power Meter Test Setup, with the power meter connected to the antenna 1 SMA connector. 2. Execute IP initialization procedure in Section 6.2.3.2.	N/A	N/A
1.	Set the WRM *unit mode* to *RSU*.	1. Use the API Tester to set the WRM unit mode to RSU. 2. Use the API Tester to get the current WRM configuration and verify the response.	API Tester displays unit mode as RSU.	RSU
	Set the channel, antenna compensation factor, and power setting.	3. Use the API Tester to set the WRM configuration to channel 172, antenna1 compensation as 0 and power level as 10. 4. Use the API Tester to get the WRM configuration and verify the response for the above commands.	API Tester displays channel 172, antenna1 compensation as 0, and power level as 10.	Channel = 172 Antenna 1 Comp = 0 Tx Power = 10 dBm
	Verify the power output level at the SMA antenna connector.	5. Use the API Tester to continuously broadcast packets w/o PBP control. 6. Measure the transmit power at the antenna 1 SMA connector using the power meter.	Power meter displays antenna 1 power = 10 dBm +/- 1 dB.	12.0 dBm
	Verify the power output level for other parameter settings.	7. Repeat steps 3-6 using the combinations of channel, antenna compensation factor, and power levels listed in Table 6-67.	See Table 6-67.	Record results in Table 6-67.
2.	Set the antenna to 2.	1. Use the API Tester to set the antenna to 2. 2. Use API Tester to get the WRM configuration and verify the response. 3. Connect the power meter to the antenna 2 SMA connector.	API Tester displays antenna 2.	Antenna = 2
	Verify the output power levels.	4. Execute Test Case # 1, steps 3-7 using the combinations of channel, antenna compensation factor, and power levels listed in Table 6-68. Measure output power at the antenna 2 SMA connector.	See Table 6-68.	Record results in Table 6-68.

Table 6-67. RSU Power Limiting at Antenna 1 IP Configuration Test Results

Channel	Ant. Input Limit (dBm)	Antenna Comp.	Power	Expected Results (dBm)	Actual Results (dBm)				
					Channel 172	Channel 174	Channel 176	Channel 178	Channel 184
172, 174, 176, 178, 184	28.8	0	10	10	12.0	11.7	11.9	11.9	11.8
			15	15	16.5	16.3	16.0	16.0	16.1
			20	20	20.4	20.1	19.9	20.0	20.0
		10	10	10	12.2	11.6	11.7	11.8	11.6
			15	15	16.6	16.4	16.3	16.2	16.5
			20	19	19.7	19.3	19.1	19.2	19.6
		19	10	10	12.0	11.9	11.6	11.7	11.8
			15	10	11.9	11.8	11.7	11.8	11.6
			20	10	12.0	11.8	11.5	11.6	11.7
					Channel 175	Channel 180	Channel 181	Channel 182	
175, 180, 181, 182	10.0	-10	0	0	-0.3	0.1	-0.1	0.1	
			10	10	11.2	12.0	11.3	12.2	
			20	20	19.3	20.1	19.5	20.4	
		-5	0	0	-0.3	0.0	-0.2	0.1	
			10	10	11.2	12.1	11.4	12.0	
			20	15	15.7	16.4	15.8	16.5	
		0	0	0	-0.3	0.1	-0.3	0.1	
			10	10	11.2	12.2	11.1	12.0	
			20	10	11.2	12.2	11.1	12.0	

Table 6-68. RSU Power Limiting at Antenna 2 IP Configuration Test Results

Channel	Ant. Input Limit (dBm)	Antenna Comp.	Power	Expected Results (dBm)	Actual Results (dBm)				
					Channel 172	Channel 174	Channel 176	Channel 178	Channel 184
172, 174, 176, 178, 184	28.8	0	10	10	10.4	10.9	11.3	11.4	10.3
			15	15	15.3	15.6	16.0	16.1	15.1
			20	20	18.8	19.2	19.8	19.8	19.0
		10	10	10	10.4	11.2	11.3	11.7	10.4
			15	15	15.2	15.5	16.1	16.0	15.2

Channel	Ant. Input Limit (dBm)	Antenna Comp.	Power	Expected Results (dBm)	Actual Results (dBm)				
					Channel 172	**Channel 174**	**Channel 176**	**Channel 178**	**Channel 184**
			20	19	18.0	18.7	19.2	19.1	18.3
		19	10	10	10.2	10.8	11.2	11.2	10.6
			15	10	10.3	10.9	11.3	11.3	10.4
			20	10	10.2	11.0	11.2	11.4	10.4
					Channel 175	**Channel 180**	**Channel 181**	**Channel 182**	
175, 180, 181, 182	10.0	-10	0	0	-1.1	-1.1	-1.3	-1.3	
			10	10	10.5	10.9	10.1	10.7	
			20	20	18.7	19.3	18.4	18.9	
		-5	0	0	-1.1	-1.0	-1.3	-1.5	
			10	10	10.3	11.3	10.0	10.4	
			20	15	15.1	16.0	14.8	15.4	
		0	0	0	-1.0	-1.0	-1.4	-1.4	
			10	10	10.3	10.9	10.0	10.4	
			20	10	10.3	10.9	10.0	10.5	

RSU Power Limiting Packet-by-Packet IP Test

Table 6-69. RSU Power Limiting Packet-by-Packet IP Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization	1. Use the test setup shown in Figure 6-5. WRM with Power Meter Test Setup, with the power meter connected to the antenna 1 SMA connector. 2. Execute IP initialization procedure in Section 6.2.3.2.	N/A	N/A
1.	Set the WRM *unit mode* to *RSU*, channel, antenna compensation factor, and power setting for use by PBP control.	1. Use the API Tester to set the antenna 1 compensation to 0 using IP Configuration. 2. Use the API Tester to set the WRM *unit mode* to *RSU*, channel to 172, and power level as 10.	N/A	N/A
	Verify the power output level at the SMA antenna connector.	3. Use the API Tester to continuously broadcast packets with PBP control. 4. Measure the transmit power at the antenna 1 SMA connector using the power meter.	Power meter displays antenna 1 power = 10 dBm +/- 1 dB.	12.0 dBm
		5. Use the API Tester to stop packet broadcast.	N/A	N/A
	Verify the power output level for other parameter settings.	6. Repeat steps 1-5 using the combinations of channel, antenna compensation factor, and power levels listed in 7. Table 6-70.	See Table 6-70.	Record results in Table 6-70.
2.	Set the antenna to 2.	1. Use the API Tester to set the antenna to 2 for PBP control.	N/A	
	Verify the output power levels.	2. Execute Test Case # 1, steps 1-6 using the combinations of channel, antenna compensation factor, and power levels listed in Table 6-71. Measure output power at the antenna 2 SMA connector.	See Table 6-71.	Record results in Table 6-71.

Table 6-70. RSU Power Limiting at Antenna 1 Packet-by-Packet IP Test Results

Channel	Ant. Input Limit (dBm)	Antenna Comp.	Power	Expected Results (dBm)	Actual Results (dBm)				
					Channel 172	Channel 174	Channel 176	Channel 178	Channel 184
172, 174, 176, 178, 184	28.8	0	10	10	12.0	11.7	11.8	11.9	11.9
			15	15	16.4	16.1	16.2	16.1	16.3
			20	20	20.2	20.1	20.0	20.0	20.1
		10	10	10	12.0	11.7	11.8	11.8	11.8
			15	15	16.4	16.3	16.3	16.1	16.5
			20	19	19.7	19.6	19.3	19.5	19.6
		19	10	10	12.0	11.8	11.8	11.9	11.9
			15	10	12.1	12.0	11.7	11.8	11.8
			20	10	12.2	11.9	11.7	11.8	11.8
					Channel 175	Channel 180	Channel 181	Channel 182	
175, 180, 181, 182	10.0	-10	0	0	-0.3	0.1	0.0	0.0	
			10	10	11.2	12.3	11.6	12.3	
			20	20	19.4	20.3	19.8	20.4	
		-5	0	0	-0.3	0.1	0.0	0.1	
			10	10	11.3	12.0	11.5	12.1	
			20	15	15.7	16.4	16.0	16.5	
		0	0	0	-0.3	0.1	-0.1	0.1	
			10	10	11.3	12.1	11.6	12.2	
			20	10	11.3	12.0	11.6	12.1	

Table 6-71. RSU Power Limiting at Antenna 2 Packet-by-Packet IP Test Results

Channel	Ant. Input Limit (dBm)	Antenna Comp.	Power	Expected Results (dBm)	Actual Results (dBm)				
					Channel 172	Channel 174	Channel 176	Channel 178	Channel 184
172, 174, 176, 178, 184	28.8	0	10	10	10.3	11.0	11.3	11.3	10.8
			15	15	15.1	15.5	15.9	15.9	15.2
			20	20	18.7	19.2	19.7	19.7	19.0
		10	10	10	10.4	10.7	11.5	11.4	10.7
			15	15	15.0	15.6	16.0	15.9	15.1
			20	19	18.1	18.6	19.1	19.1	18.3
		19	10	10	10.3	10.7	11.2	11.2	10.7
			15	10	10.3	10.7	11.2	11.2	10.7
			20	10	10.3	10.7	11.2	11.2	10.7
					Channel 175	Channel 180	Channel 181	Channel 182	
175, 180, 181, 182	10.0	-10	0	0	-0.9	-1.0	-1.3	-1.4	
			10	10	10.3	10.9	10.0	10.5	
			20	20	18.9	19.3	18.4	18.9	
		-5	0	0	-0.9	-0.9	-1.3	-1.5	
			10	10	10.4	10.9	10.0	10.9	
			20	15	15.1	15.7	14.7	15.2	
		0	0	0	-0.9	-1.0	-1.3	-1.3	
			10	10	10.5	10.8	10.4	10.7	
			20	10	10.5	10.9	10.4	10.8	

OBU Power Limiting Telnet Test

Table 6-72. OBU Power Limiting Telnet Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization	1. Use the test setup shown in Figure 6-5. WRM with Power Meter Test Setup, with the power meter connected to the antenna 1 SMA connector. 2. Execute Telnet initialization procedure in Section 6.2.3.1.	N/A	N/A
1.	Set the WRM unit mode to OBU.	1. Use the API Tester to send the *set unitmode OBU* Telnet command and verify the response.	API Tester displays response: *Unit Mode: OBU.*	Unit Mode: OBU
	Set the channel, antenna compensation factor, and power setting.	2. Use the API Tester to send the *set channel 172* Telnet command. 3. Use the API Tester to send the *set antenna1comp –5* Telnet command. 4. Use the API Tester to send the *set power 9* Telnet command. 5. Use the API Tester to verify the response for the above commands.	API Tester displays response: *Radio Frequency: 5860 MHz (IEEE 172).* API Tester displays response: *Antenna1comp: -5.* API Tester displays response: *Transmit Power: 9.*	Radio Frequency: 5860 MHz (IEEE 172) Antenna 1 Comp: -5 Transmit Power: 9 dBm
	Verify the output power level at the SMA antenna connector.	6. Use the API Tester to continuously broadcast packets. 7. Measure the transmit power at the antenna 1 SMA connector using the power meter.	Power meter displays antenna 1 power = 9dBm +/- 1 dB.	11.0 dBm
		8. Use the API Tester to stop packet broadcast.	N/A	N/A
	Verify the output power level for other parameter settings.	9. Repeat steps 2-8 using the combinations of channel, antenna compensation factor, and power levels listed in Table 6-73.	See Table 6-73.	Record results in Table 6-73.
2.	Set the antenna to 2.	1. Use the API Tester to send the *set antenna 2* Telnet command and verify the response. 2. Connect the power meter to the antenna 2 SMA connector.	API Tester display response: *Antenna: 2.*	Antenna: 2
	Verify output power levels.	3. Execute Test Case # 1, steps 2-9 using the combinations of channel, antenna compensation factor, and power levels listed in Table 6-74. Measure output power at the antenna 2 SMA connector.	See Table 6-74.	Record results in Table 6-74.

Table 6-73. OBU Power Limiting at Antenna 1 Telnet Test Results

Channel	Ant. Input Limit (dBm)	Antenna Comp.	Power	Expected Results (dBm)	Actual Results (dBm)				
					Channel 172	Channel 174	Channel 176	Channel 178	Channel 184
172, 174, 176, 178, 184	28.8	0	10	10	12.0	11.6	11.8	11.8	11.8
			15	15	16.6	16.1	16.0	16.4	16.8
			20	20	20.4	20.1	19.9	20.0	20.1
		10	10	10	11.9	12.0	11.4	11.9	11.8
			15	15	16.7	16.2	15.9	16.2	16.3
			20	19	19.5	19.4	19.2	19.3	19.6
		19	10	10	12.0	12.1	11.7	11.8	11.9
			15	10	12.1	12.0	11.8	11.9	11.9
			20	10	12.2	11.9	11.8	11.9	12.0
					Channel 175				
175	10.0	-10	0	0	-0.3				
			10	10	11.0				
			20	20	19.3				
		-5	0	0	-0.3				
			10	10	11.3				
			20	15	15.7				
		0	0	0	-0.3				
			10	10	11.0	**Channel 180**	**Channel 181**	**Channel 182**	
			20	10	11.0				
180, 181, 182	20.0	0	10	10		12.0	11.5	12.3	
			15	15		16.8	15.8	16.6	
			20	20		20.1	19.5	20.2	
		5	10	10		12.0	11.6	12.1	
			15	15		16.4	16.0	16.6	
			20	15		16.5	15.9	16.5	
		10	10	10		12.2	11.6	12.0	
			15	10		12.2	11.6	12.0	
			20	10		12.2	11.5	12.1	

Table 6-74. OBU Power Limiting at Antenna 2 Telnet Test Results

Channel	Ant. Input Limit (dBm)	Antenna Comp.	Power	Expected Results (dBm)	Actual Results (dBm)				
					Channel 172	Channel 174	Channel 176	Channel 178	Channel 184
172, 174, 176, 178, 184	28.8	0	10	10	10.6	11.0	11.2	11.5	10.8
			15	15	15.2	15.7	16.0	16.3	15.4
			20	20	18.6	19.0	19.7	19.9	19.0
		10	10	10	10.5	10.6	11.1	11.6	10.7
			15	15	14.9	15.3	15.8	16.1	15.1
			20	19	18.0	18.6	19.0	19.3	18.4
		19	10	10	10.5	10.7	11.3	11.7	10.4
			15	10	10.5	10.8	11.3	11.8	10.4
			20	10	10.5	10.7	11.3	11.4	10.4
					Channel 175				
175	10.0	-10	0	0	-1.2				
			10	10	10.4				
			20	20	18.7				
		-5	0	0	-1.1				
			10	10	10.5				
			20	15	15.0				
		0	0	0	-1.1				
			10	10	10.5	**Channel 180**	**Channel 181**	**Channel 182**	
			20	10	10.5				
180, 181, 182	20.0	0	10	10		11.0	10.1	10.5	
			15	15		16.1	15.0	15.3	
			20	20		19.4	18.4	19.0	
		5	10	10		11.0	10.0	10.5	
			15	15		15.6	15.0	15.3	
			20	15		15.6	15.1	15.2	
		10	10	10		10.9	10.5	10.6	
			15	10		10.9	10.5	10.6	
			20	10		10.9	10.5	10.5	

OBU Power Limiting IP Configuration Test

Table 6-75. OBU Power Limiting IP Configuration Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization	1. Use the test setup shown in Figure 6-5. WRM with Power Meter Test Setup, with the power meter connected to the antenna 1 SMA connector. 2. Execute IP initialization procedure in Section 6.2.3.2.	N/A	N/A
1.	Set the WRM *unit mode* to *OBU*.	1. Use the API Tester to set the WRM *unit mode* to *OBU*. 2. Use the API Tester to get the current WRM configuration and verify the response.	API Tester displays unit mode as OBU.	Unit Mode = OBU
	Set the channel, antenna compensation factor, and power setting.	3. Use the API Tester to set the WRM configuration to channel 172, antenna1 compensation as 0 and power level as 10. 4. Use the API Tester to get the WRM configuration and verify the response for the above commands.	API Tester displays channel 172, antenna1 compensation as 0 and power level as 10.	Channel = 172 Antenna 1 Comp = 0 Tx Power = 10
	Verify the output power level at the SMA antenna connector.	5. Use the API Tester to continuously broadcast packets w/o PbP control. 6. Measure the transmit power at the antenna 1 SMA connector using the power meter.	Power meter displays antenna 1 power = 10 dBm +/- 1 dB.	12.0 dBm
		7. Use the API Tester to stop packet broadcast.	N/A	N/A
	Verify the output power level for other parameter settings.	8. Repeat steps 3-7 using the combinations of channel, antenna compensation factor, and power levels listed in 9. Table 6-76.	See Table 6-76.	Record results in Table 6-76
2.	Set the antenna to 2.	1. Use the API Tester to set the antenna to 2. 2. Use API Tester to get the WRM configuration and verify the response. 3. Connect the power meter to the antenna 2 SMA connector.	API Tester displays antenna 2.	Antenna = 2

#	Description	Test Steps	Expected Results	Actual Results
	Verify output power levels.	4. Execute Test Case # 1, steps 3-8 using the combinations of channel, antenna compensation factor, and power levels listed in **Table 6-77**. Measure output power of antenna 2 instead of antenna 1.	See **Table 6-77**.	Record results in **Table 6-77**

Table 6-76. OBU Power Limiting at Antenna 1 IP Configuration Test Results

Channel	Ant. Input Limit (dBm)	Antenna Comp.	Power	Expected Results (dBm)	Actual Results (dBm)				
					Channel 172	Channel 174	Channel 176	Channel 178	Channel 184
172, 174, 176, 178, 184	28.8	0	10	10	12.0	11.9	11.5	11.9	11.8
			15	15	16.8	16.5	16.2	16.1	16.3
			20	20	20.2	20.1	19.9	20.0	20.1
		10	10	10	12.0	11.8	11.8	11.7	11.8
			15	15	16.5	16.2	16.1	16.4	16.3
			20	19	19.8	19.5	19.2	19.3	19.4
		19	10	10	12.2	12.0	11.8	11.6	11.8
			15	10	12.2	12.0	11.6	11.6	11.8
			20	10	12.0	12.0	11.7	11.6	11.7
					Channel 175				
175	10.0	-10	0	0	-0.4				
			10	10	11.0				
			20	20	19.3				
		-5	0	0	-0.4				
			10	10	11.1				
			20	15	15.7				
		0	0	0	-0.4				
			10	10	11.1	**Channel 180**	**Channel 181**	**Channel 182**	
			20	10	11.1				
180, 181, 182	20.0	0	10	10		12.0	11.4	12.0	
			15	15		16.5	15.7	16.7	
			20	20		20.3	19.6	20.3	
		5	10	10		11.9	11.4	12.0	
			15	15		16.6	15.9	16.7	
			20	15		16.5	16.0	16.7	
		10	10	10		12.1	11.3	12.2	
			15	10		12.1	11.3	12.2	
			20	10		12.1	11.5	12.1	

Table 6-77. OBU Power Limiting at Antenna 2 IP Configuration Test Results

Channel	Ant. Input Limit (dBm)	Antenna Comp.	Power	Expected Results (dBm)	Actual Results (dBm)				
					Channel 172	Channel 174	Channel 176	Channel 178	Channel 184
172, 174, 176, 178, 184	28.8	0	10	10	10.2	10.5	11.4	11.4	10.7
			15	15	14.9	15.2	15.8	16.3	15.2
			20	20	18.5	19.0	19.6	19.9	18.9
		10	10	10	10.2	10.5	11.2	11.2	10.4
			15	15	14.9	15.3	16.0	16.0	15.0
			20	19	17.9	18.5	18.9	19.2	18.3
		19	10	10	10.3	10.5	11.3	11.3	10.6
			15	10	10.3	10.5	11.3	11.3	10.6
			20	10	10.4	10.5	11.4	11.3	10.6
					Channel 175				
175	10.0	-10	0	0	-1.2				
			10	10	10.2				
			20	20	18.6				
		-5	0	0	-1.1				
			10	10	10.2				
			20	15	14.9				
		0	0	0	-1.1				
			10	10	10.2	**Channel 180**	**Channel 181**	**Channel 182**	
			20	10	10.2				
180, 181, 182	20.0	0	10	10		11.2	10.2	10.7	
			15	15		15.7	14.8	15.4	
			20	20		19.4	18.5	18.9	
		5	10	10		11.2	10.2	10.6	
			15	15		15.6	14.7	15.6	
			20	15		15.9	14.8	15.5	
		10	10	10		11.2	10.2	10.7	
			15	10		11.1	10.3	10.6	
			20	10		11.1	10.3	10.7	

6.3.3.8 Data Rate

Verify the WRM supports all data rates specified by ASTM E2213-03 for channels operating with a 10 MHz bandwidth. Verify the WRM supports all data rates specified by IEEE 802.11a for channels operating with a 20 MHz bandwidth.

Test Cases:

1. 10 MHz Data Rates
2. 20 MHz Data Rates

Data Rate Telnet Test

Table 6-78. Data Rate Telnet Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization.	1. Use the test setup shown in Figure 6-6. WRM with Vector Signal Analyzer Test Setup. 2. Execute Telnet initialization procedure in Section 6.2.3.1.	N/A	N/A
1.	Verify WRM response to *set rate 3* command.	1. Use the API Tester to send the *set rate 3* command and verify the response.	API Tester displays response: *Data Rate: 3*	Data Rate: 3
	Verify the WRM response to *get rate* command.	2. Use the API Tester to send the *get rate* Telnet command and verify the response.	API Tester displays response: *Data Rate: 3.*	Data Rate: 3
	Verify WRM operation.	3. Use the API Tester to continuously broadcast packets w/o PBP control. 4. Use VSA to verify WRM is transmitting at the 3 Mbps data rate.	VSA shows WRM is transmitting at 3 Mbps.	3 Mbps
		5. Use the API Tester to stop packet broadcast.	N/A	N/A
	Verify all remaining 10 MHz data rates.	6. Repeat steps 1-5 for all data rates listed in Table 6-79.	API Tester displays WRM response showing selected data rate. VSA verifies data rate is correct.	Record results in Table 6-79
2.	Switch to 20 MHz channel.	1. Use API Tester to send command *set fastchannel 52* and verify the response.	API Tester displays response: *Radio Frequency: 5260 MHz (IEEE 52).*	Radio Frequency: 5260 (IEEE 52)
	Verify all 20 MHz data rates.	2. Repeat Test Case # 1, steps 1-5 for all data rates listed in Table 6-80.	API Tester displays WRM response showing selected data rate. VSA verifies data rate is correct.	Record results in Table 6-80

Table 6-79. 10MHz Channel Data Rate Telnet Test Results

Data Rate	Expected Results			Actual Results		
	set data rate	*get data rate*	VSA	*set data rate*	*get data rate*	VSA
4.5	4.5	4.5	4.5	4.5	4.5	4.5 Mbps
6	6	6	6	6	6	6 Mbps
9	9	9	9	9	9	9 Mbps
12	12	12	12	12	12	12 Mbps
18	18	18	18	18	18	18 Mbps
24	24	24	24	24	24	24 Mbps
27	27	27	27	27	27	27 Mbps

Table 6-80. 20MHz Channel Data Rate Telnet Test Results

Data Rate	Expected Results			Actual Results		
	set data rate	*get data rate*	VSA	*set data rate*	*get data rate*	VSA
6	6	6	6	6	6	6 Mbps
9	9	9	9	9	9	9 Mbps
12	12	12	12	12	12	12 Mbps
18	18	18	18	18	18	18 Mbps
24	24	24	24	24	24	24 Mbps
36	36	36	36	36	36	36 Mbps
48	48	48	48	48	48	48 Mbps
54	54	54	54	54	54	54 Mbps

Data Rate IP Configuration Test

Table 6-81. Data Rate IP Configuration Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization.	1. Use the test setup shown in Figure 6-6. WRM with Vector Signal Analyzer Test Setup. 2. Execute IP initialization procedure in Section 6.3.1.2.	N/A	N/A
1.	Set WRM *rate* to *3*.	1. Use the API Tester to set the WRM configuration with a rate of 3. 2. Use Ethereal to verify the WCO rate field.	API Tester sends WCO with rate field (Word 1, Bits 28-31) set to 0001.	(W1) DD 14 11 41 1101 1101 0001 0100 0001 0001 0100 0001
	Verify the WRM rate configuration.	3. Use the API Tester to get the WRM configuration. 4. Use Ethereal to verify WCO rate field.	WRM sends WCO with rate field (Word 1, Bits 28-31) set to 0001.	(W1) DD 14 11 41
		5. Use the API Tester to verify the WRM configuration.	API Tester displays 3 Mbps.	Data rate = 3
	Verify WRM operation.	6. Use the API Tester to continuously broadcast packets w/o PBP control. 7. Use VSA to verify WRM is transmitting at the 3 Mbps data rate.	VSA shows WRM is transmitting at 3 Mbps.	VSA shows 3 Mbps
		8. Use API Tester to stop packet broadcast.	N/A	N/A
	Verify all remaining 10 MHz data rates.	9. Repeat steps 1-8 for all data rates listed in Table 6-82.	WCOs contain rate values in accordance with Table 6-82. API Tester displays WRM response showing selected data rate. VSA verifies data rate is correct.	Record results in Table 6-82.
2.	Switch to 20 MHz channel.	1. Use API Tester to send command set the WRM configuration to channel 52. 2. Use the API Tester to get the WRM configuration.	API Tester displays channel 52.	052 (5260 MHz) – 802.11a
	Verify all 20 MHz data rates.	3. Repeat Test Case # 1, steps 1-8 for all data rates listed in Table 6-83.	WCOs contain rate values in accordance with Table 6-83. API Tester displays WRM response showing selected data rate. VSA verifies data rate is correct.	Record results in Table 6-83.

Table 6-82. 10 MHz Channel Data Rate IP Configuration Test Results

Data Rate	Expected Results				Actual Results			
	WCO rate field		API Tester	VSA	WCO rate field		API Tester	VSA
	Set	Get			Set	Get		
4.5	0010	0010	4.5	4.5	0010	0010	4.5	4.5 Mbps
6	0011	0011	6	6	0011	0011	6	6 Mbps
9	0100	0100	9	9	0100	0100	9	9 Mbps
12	0101	0101	12	12	0101	0101	12	12 Mbps
18	0110	0110	18	18	0110	0110	18	18 Mbps
24	0111	0111	24	24	0111	0111	24	24 Mbps
27	1000	1000	27	27	1000	1000	27	27 Mbps

Table 6-83. 20 MHz Channel Data Rate IP Configuration Test Results

Data Rate	Expected Results				Actual Results			
	WCO rate field		API Tester	VSA	WCO rate field		API Tester	VSA
	Set	Get			Set	Get		
6	0001	0001	6	6	0001	0001	6	6 Mbps
9	0010	0010	9	9	0010	0010	9	9 Mbps
12	0011	0011	12	12	0011	0011	12	12 Mbps
18	0100	0100	18	18	0100	0100	18	18 Mbps
24	0101	0101	24	24	0101	0101	24	24 Mbps
36	0110	0110	36	36	0110	0110	36	36 Mbps
48	0111	0111	48	48	0111	0111	48	48 Mbps
54	1000	1000	54	54	1000	1000	54	54 Mbps

Data Rate IP Packet-by-Packet Test

Table 6-84. Data Rate IP Packet-by-Packet Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization.	1. Use the test setup shown in Figure 6-6. WRM with Vector Signal Analyzer Test Setup. 2. Execute IP initialization procedure in Section 6.3.1.2.	N/A	N/A
1.	Set WRM *rate to 3* using PBP control.	1. Use the API Tester to set the WRM configuration with a *rate* of *3* and transmit one packet with PBP control. 2. Use Ethereal to verify the WTXO rate field.	API Tester sends WTXO with Data Rate field (Word 1, Bits 28-31) set to 0001.	(W1) D9 10 11 41 1101 1001 0001 0000 0001 0001 0100 0001
	Verify WRM configuration.	3. Use the API Tester to get the WRM configuration.	API Tester displays data rate of 3 Mbps.	3 Mbps
	Verify WRM data rate.	4. Use the API Tester to continuously broadcast packets. 5. Use VSA to verify WRM is transmitting at 3 Mbps.	VSA shows WRM is transmitting at 3 Mbps.	3 Mbps
		6. Use the API Tester to stop packet broadcast.	N/A	N/A
	Verify remaining 10 MHz rates.	7. Repeat steps 1-6 for all data rates listed in Table 6-85.	WTXO rate field values are in accordance with Table 6-85. VSA verifies WRM is transmitting at correct rate.	Record results in Table 6-85.
2.	Switch to 20 MHz channel.	1. Use API Tester to set the WRM configuration to channel 52. 2. Use the API Tester to get the WRM configuration and verify the response.	API Tester displays channel 52.	052 (5260 MHz) – 802.11a
	Verify all 20 MHz data rates.	3. Repeat Test Case # 1, steps 1-6 for all data rates listed in Table 6-86.	WTXO rate field values are in accordance with Table 6-86. VSA verifies WRM is transmitting at correct rate.	Record results in Table 6-86.

Table 6-85. 10MHz Channel Data Rate IP Packet-by-Packet Test Results

Data Rate	Expected Results			Actual Results		
	WTXO rate field	API Tester	VSA	WTXO rate field	API Tester	VSA
4.5	0010	4.5	4.5	0010	4.5	4.5 Mbps
6	0011	6	6	0011	6	6 Mbps
9	0100	9	9	0100	9	9 Mbps
12	0101	12	12	0101	12	12 Mbps
18	0110	18	18	0110	18	18 Mbps
24	0111	24	24	0111	24	24 Mbps
27	1000	27	27	1000	27	27 Mbps

Table 6-86. 20MHz Channel Data Rate IP Packet-by-Packet Test Results

Data Rate	Expected Results			Actual Results		
	WTXO rate field	API Tester	VSA	WTXO rate field	API Tester	VSA
6	0001	6	6	0001	6	6 Mbps
9	0010	9	9	0010	9	9 Mbps
12	0011	12	12	0011	12	12 Mbps
18	0100	18	18	0100	18	18 Mbps
24	0101	24	24	0101	24	24 Mbps
36	0110	36	36	0110	36	36 Mbps
48	0111	48	48	0111	48	48 Mbps
54	1000	54	54	1000	54	54 Mbps

6.3.3.9 RTS Threshold

Verify the WRM supports setting the RTS threshold. The valid range of values is 256 to 2346 bytes. For these tests, the step attenuators are setup to provide a 10dB difference between the two WRM transmit power levels. This allows the test operator to identify the origin of packet transmissions captured by the Vector Signal Analyzer.

Test Cases:

1. No RTS on Service Channel when RTS Threshold is set higher than MAC packet length.
2. RTS/CTS performed on Service Channel when RTS Threshold is set lower than MAC packet length.
3. No RTS on Control Channel.

RTS Threshold Telnet Test

Table 6-87. RTS Threshold Telnet Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization	1. Use test setup shown in Figure 6-9. WRMs with Step Attenuators and Vector Signal Analyzer Test Setup. 2. Execute the Telnet initialization procedure in Section 6.2.3.1 on both HD/WRM setups. 3. Adjust step attenuator connected to WRM-1antenna to 20 dB. 4. Adjust step attenuator connected to WRM-2 antenna to 30 dB.	N/A	N/A
1.	Verify WRM does not perform RTS/CTS on Service Channel when MAC packet size is less than RTS threshold.	1. Use the HD-1 API Tester to send the *set fastchannel 172* Telnet command.	HD-1 API Tester displays response: *Radio Frequency: 5860 MHz (IEEE 172).*	Radio Frequency: 5860 (IEEE 172)
		2. Use the HD-2 API Tester to send the *set fastchannel 172* Telnet command.	HD-2 API Tester displays response: *Radio Frequency: 5860 MHz (IEEE 172).*	Radio Frequency 5860 (IEEE 172)
		3. Use the HD-1 API Tester to send the *get rtsthreshold* Telnet command.	HD-1 API Tester displays response: *RTS Threshold: 2346*	RTS/CTS Threshold: 2346
		4. Use the HD-2 API Tester to get the MAC address of WRM-2.	HD-2 API Tester displays the MAC address of WRM-2.	F2:AB:B9:06:F8:BC

#	Description	Test Steps	Expected Results	Actual Results
		5. Use the HD-1 API Tester to transmit a single 1400 byte data packet w/o PBP control to WRM-2 MAC address. 6. Use the VSA to display the data packet transmission.	VSA displays WRM-1 data packet transmitted at 0dBm, followed by short WRM-2 ACK transmitted at –10dBm.	Data packet transmitted at +2 dBm. ACK transmitted at –10 dBm.
2.	Verify WRM performs RTS/CTS on Service Channel when MAC packet size exceeds RTS threshold.	1. Use the HD-1 API Tester to send the *set fastchannel 172* Telnet command.	HD-1 API Tester displays response: *Radio Frequency: 5860 MHz (IEEE 172).*	Radio Frequency: 5860 MHz (IEEE 172)
		2. Use the HD-2 API Tester to send the *set fastchannel 172* Telnet command.	HD-2 API Tester displays response: *Radio Frequency: 5860 MHz (IEEE 172).*	Radio Frequency: 5860 MHz (IEEE 172)
		3. Use the HD-1API Tester to send the *set rtsthreshold 1000* Telnet command.	HD-1 API Tester displays response: *RTS Threshold: 1000*	RTS/CTS Threshold: 1000
		4. Use the HD-1 API Tester to transmit a single 1400 byte data packet w/o PBP control to WRM-2 MAC address. 5. Use the VSA to display the data packet transmission.	VSA displays short WRM-1 RTS transmitted at 0 dBm, followed by short WRM-2 CTS transmitted at –10 dBm, followed WRM-1 data packet transmitted at 0dBm, followed by short WRM-2 ACK transmitted at –10dBm.	RTS transmitted at +2 dBm. CTS transmitted at –10 dBm. Data transmitted at +2 dBm. ACK transmitted at –10 dBm.
3.	Verify WRM does not perform RTS/CTS on Control Channel even though MAC packet size exceeds RTS threshold.	1. Use the HD-1 API Tester to send the *set fastchannel 178* Telnet command.	HD-1 API Tester displays response: *Radio Frequency: 5890 MHz (IEEE 178).*	Radio Frequency: 5890 (IEEE178)
		2. Use the HD-2 API Tester to send the *set fastchannel 178* Telnet command.	HD-2 API Tester displays response: *Radio Frequency: 5890 MHz (IEEE 178).*	Radio Frequency: 5890 (IEEE 178)
		3. Use the HD-1API Tester to send the *set rtsthreshold 1000* Telnet command.	HD-1 API Tester displays response: *RTS Threshold: 1000*	RTS/CTS Threshold: 1000
		4. Use the HD-1 API Tester to transmit a single 1400 byte data packet w/o PBP control to WRM-2 MAC address. 5. Use the VSA to display the data packet transmission.	VSA displays WRM-1 data packet transmitted at 0dBm, followed by short WRM-2 ACK transmitted at –10dBm.	Data transmitted at +2 dBm. ACK transmitted at –10 dBm.

RTS Threshold IP Configuration Test

Table 6-88. RTS Threshold IP Configuration Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization	1. Use test setup shown in Figure 6-9. WRMs with Step Attenuators and Vector Signal Analyzer Test Setup. 2. Execute the IP initialization procedure in Section 6.3.1.2 on both HD/WRM setups. 3. Adjust step attenuator connected to WRM-1antenna to 20 dBm. 4. Adjust step attenuator connected to WRM-2 antenna to 30 dBm.	N/A	N/A
1.	Verify WRM does not perform RTS/CTS on Service Channel when MAC packet size is less than RTS threshold.	1. Use the HD-1 API Tester to set the WRM channel to 172.	HD-1 API Tester displays Channel 172.	172 (5860 MHz) – WAVE
		2. Use the HD-2 API Tester to set the WRM channel to 172.	HD-2 API Tester displays Channel 172.	172 (5860 MHz) – WAVE
		3. Use the HD-1 API Tester to get the WRM configuration and verify the *RTS Threshold*	API Tester displays RTS Threshold of 2346 bytes.	RTS Threshold 1000
		4. Use the HD-2 API Tester to get the MAC address of WRM-2.	HD-2 API Tester displays the MAC address of WRM-2.	46:87:1A:9C:FB:29
		5. Use the HD-1 API Tester to transmit a single 1400 byte data packet w/o PBP control to WRM-2 MAC address. 6. Use the VSA to display the data packet transmission.	VSA displays WRM-1 data packet transmitted at 0dBm, followed by short WRM-2 ACK transmitted at –10dBm.	Data transmitted at +2 dBm. ACK transmitted at –10 dBm.
2.	Verify WRM performs RTS/CTS on Service Channel when MAC packet size exceeds RTS threshold.	1. Use the HD-1 API Tester to set the WRM channel to 172.	HD-1 API Tester displays Channel 172.	172 (5860 MHz) – WAVE
		2. Use the HD-2 API Tester to set the WRM channel to 172.	HD-2 API Tester displays Channel 172.	172 (5860 MHz) – WAVE
		3. Use HD-1 API Tester to set the RTS Threshold to 1000 bytes. 4. Use Ethereal to verify the WCO RTS Threshold field.	API Tester sends WCO with RTS Threshold field (Word 2, bits 16-31) set to 1000 (x03E8).	(W2) 09 2A **03 E8**

#	Description	Test Steps	Expected Results	Actual Results
		5. Use the HD-1 API Tester to transmit a single 1400 byte data packet w/o PBP control to WRM-2 MAC address. 6. Use the VSA to display the data packet transmission.	VSA displays short WRM-1 RTS transmitted at 0 dBm, followed by short WRM-2 CTS transmitted at –10 dBm, followed WRM-1 data packet transmitted at 0dBm, followed by short WRM-2 ACK transmitted at –10dBm.	RTS at +2 dBm, CTS at –10 dBm, Data at +2 dBm, ACK at –10 dBm.
3.	Verify WRM does not perform RTS/CTS on Control Channel even though MAC packet size exceeds RTS threshold.	1. Use the HD-1 API Tester to set the WRM channel to 178.	HD-1 API Tester displays Channel 178.	178 (5890 MHz) – WAVE
		2. Use the HD-2 API Tester to set the WRM channel to 178.	HD-2 API Tester displays Channel 178.	Channel = 178
		3. Use HD-1 API Tester to set the RTS Threshold to 1000 bytes. 4. Use Ethereal to verify the WCO RTS Threshold field.	API Tester sends WCO with RTS Threshold field (Word 2, bits 16-31) set to 1000 (x03E8).	(W2) 09 2A **03 E8**
		5. Use the HD-1 API Tester to transmit a single 1400 byte data packet w/o PBP control to WRM-2 MAC address. 6. Use the VSA to display the data packet transmission.	VSA displays WRM-1 data packet transmitted at 0dBm, followed by short WRM-2 ACK transmitted at –10dBm.	Data at +2 dBm, ACK at –10 dBm.

Table 6-89. RTS Threshold IP Packet-by-Packet Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization	1. Use test setup shown in Figure 6-9. WRMs with Step Attenuators and Vector Signal Analyzer Test Setup. 2. Execute the IP initialization procedure in Section 6.3.1.2 on both HD/WRM setups. 3. Adjust step attenuator connected to WRM-1antenna to 20 dBm. 4. Adjust step attenuator connected to WRM-2 antenna to 30 dBm.	N/A	N/A
1.	Verify WRM does not perform RTS/CTS on Service Channel when MAC packet size is less than RTS threshold.	1. Use the HD-2 API Tester to get the MAC address of WRM-2.	HD-2 API Tester displays the MAC address of WRM-2.	B2:E7:74:5E:40:32
		2. Use HD-2 API Tester to change channel to 172.	N/A	N/A
		3. Use the HD-1 API Tester to transmit a single 1400 byte data packet with RTS Threshold set to 1500, on channel 172, with PBP control to WRM-2 MAC address. 4. Use Ethereal to verify the WTXO RTS Threshold field.	API Tester sends WTXO with RTS Threshold field (Word 2, bits 16-31) set to 1500 (x05DC).	(W2) 09 2A 05 DC
		5. Use the VSA to display the data packet transmission.	VSA displays WRM-1 data packet transmitted at 0dBm, followed by short WRM-2 ACK transmitted at –10dBm.	Data at +2 dBm, ACK at –10 dBm
		6. Use the API Tester to stop packet transmission.	N/A	N/A
2.	Verify WRM performs on Service Channel RTS/CTS when MAC packet size exceeds RTS threshold.	1. Use the HD-1 API Tester to transmit a single 1400 byte data packet with RTS Threshold set to 1000, on channel 172, with PBP control to WRM-2 MAC address. 2. Use Ethereal to verify the WTXO RTS Threshold field.	API Tester sends WTXO with RTS Threshold field (Word 2, bits 16-31) set to 1000 (x03E8).	(W2) 09 2A 03 E8

#	Description	Test Steps	Expected Results	Actual Results
		3. Use the VSA to display the data packet transmission.	VSA displays short WRM-1 RTS transmitted at 0 dBm, followed by short WRM-2 CTS transmitted at –10 dBm, followed WRM-1 data packet transmitted at 0dBm, followed by short WRM-2 ACK transmitted at –10dBm.	RTS at +2 dBm. CTS at –10 dBm, Data at +2 dBm, ACK at –10 dBm
		4. Use the API Tester to stop packet transmission.	N/A	N/A
3.	Verify WRM does not perform RTS/CTS on Control Channel even though MAC packet size exceeds RTS threshold.	1. Use the HD-2 API Tester to get the MAC address of WRM-2.	HD-2 API Tester displays the MAC address of WRM-2.	16:2C:C8:DF:50:66
		2. Use the API Tester to transmit a single 1400 byte data packet with RTS Threshold set to 1000, on channel 178, with PBP control to WRM-2 MAC address. 3. Use Ethereal to verify the WTXO RTS Threshold field.	API Tester sends WTXO with RTS Threshold field (Word 2, bits 16-31) set to 1000 (x03E8).	(W2) 09 2A 03 E8
		4. Use the VSA to display the data packet transmission.	VSA displays WRM-1 data packet transmitted at 0dBm, followed by short WRM-2 ACK transmitted at –10dBm.	Data at +2 dBm, ACK at –10 dBm.
		5. Use the API Tester to stop packet transmission	N/A	N/A

6.3.4 Status Reporting

6.3.4.1 Configuration Parameters

Verify the WRM reports the configuration parameters. See Section 6.3.1.1 for a verification of the Telnet *get config* command. The IP Configuration tests throughout this test plan verify the WRM Configuration information obtained with the IP interface.

6.3.4.2 Hardware Version

Verify the WRM reports the hardware version. This command is only available through the Telnet interface.

Table 6-90. Hardware Version Telnet Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialize.	1. Use the test setup shown in Figure 6-1. Single WRM Test Setup. 2. Execute Telnet initialization procedure in Section 6.2.3.1.	N/A	N/A
1.	Verify the WRM response to the *get hardware* command.	1. Use the API Tester to send the *get hardware* Telnet command and verify the WRM response.	API Tester displays response: [See Note below table]	revisions: mac 5.8 phy 4.4 analog 3.6 PCI Vendor ID: 0x168c, Device ID: 0x13 Sub Vendor ID: 0x168c, Sub Device ID: 0x13

Note: WRM response is of the following format:

revisions: mac 5.7 phy 4.2 analog 3.6

PCI Vendor ID: 0x168c, Device ID: 0x13

Sub Vendor ID: 0x168c, Sub Device ID: 0x13

6.3.4.3 RSSI

Verify the WRM reports the RSSI in dBm. The RSSI is available through the Telnet and IP Packet-by-Packet interfaces.

RSSI Telnet Test

Table 6-91. RSSI Telnet Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialize.	1. Use the test setup shown in Figure 6-7. WRMs with Cable Connection. 2. Execute Telnet initialization procedure in Section 6.2.3.1 on both HD/WRM setups.	N/A	N/A
1.	Set the antenna configuration to 1.	1. Use the HD-1 and HD-2 API Testers to send the *set antenna 1* command and verify the response.	API Testers display response *Antenna: 1*.	Antenna: 1
	Verify the WRM-1 response to the *get rssi* command.	2. Adjust the WRM-2 output power and the attenuators so the input level at the WRM-1 SMA connector will be ~ –30 dBm when WRM-2 is transmitting. 3. Use the HD-2 API Tester to continuously broadcast packets with PBP control. 4. Use the HD-1 API Tester to send the *get rssi* Telnet command and verify the WRM response. 5. Use the HD-2 API Tester to stop the packet broadcast.	API Tester displays response: *rssi: -30* (+/- 1 dB)	RSSI = -30 dBm
	Verify the WRM-1 response over range of RSSI levels.	6. Repeat steps 2-5 varying the input level at the WRM-1 SMA connector from –40 to –90 dBm in 10 dB steps.	API Tester displays response: *rssi: xxx* (+/- 1 dB), where xxx is the input level.	Record the results in Table 6-92

Table 6-92. RSSI Telnet Test Results

WRM-1 SMA Input Level	HD-1 *get rssi*	
	Expected Results	Actual Results
-40	-40	-41 dBm
-50	-50	-50 dBm
-60	-60	-61 dBm
-70	-70	-70 dBm
-80	-80	-80 dBm
-90	-90	-91 dBm

RSSI IP Packet-by-Packet Test

Table 6-93. RSSI IP Packet-by-Packet Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialize.	1. Use the test setup shown in Figure 6-7. WRMs with Cable Connection. 2. Execute IP initialization procedure in Section 6.3.1.2 on both HD/WRM setups.	N/A	N/A
1.	Set antenna configuration.	1. Use the HD-1 and HD-2 API Testers to set the antenna configuration to 1. 2. Use the HD-1 and HD-2 API Testers to get the WRM configuration.	API Testers display antenna configuration as 1.	Antenna = 1
	Verify the WRM-1 provides the RSSI to HD-1.	3. Adjust the WRM-2 output power and the attenuators so the input level at the WRM-1 SMA connector will be ~ –30 dBm when WRM-2 is transmitting. 4. Use the HD-2 API Tester to broadcast one packet with PBP control. 5. Use the HD-1 Ethereal to verify the WRXO RSSI field.	WRM send WRXO with the RSSI field (Word 1, bits 16-31) to –30 (0xFFE2) +/- 1 dB	(W1) DA 24 **FF E2**
		6. Use the API Tester to verify the RSSI.	API Tester displays RSSI of –30 (+/- 1 dB)	-30 dBm
	Verify the WRM-1 response over range of RSSI levels.	7. Repeat steps 3-6 varying the WRM-1 input level from –40 to –90 dBm in 10 dB steps.	WRM sends WRXO with the RSSI field (Word 1, bits 16-31) to the input level (+/- 1 dB)	Record results in Table 6-94.

Table 6-94. RSSI IP Packet-by-Packet Tests and Results

WRM-1 SMA Input Level	Expected Results		Actual Results	
	WRXO RSSI field	API Tester	WRXO RSSI field	API Tester
-40	1111111111011000 (xFFD8)	-40	FF D7 (-41 dBm)	-41 dBm
-50	1111111111001101 (xFFCE)	-50	FF CF (-49 dBm)	-49 dBm
-60	1111111111000100 (xFFC4)	-60	FF C2 (-62 dBm)	-62 dBm
-70	1111111110111010 (xFFBA)	-70	FF BB (-69 dBm)	-69 dBm
-80	1111111110110000 (xFFB0)	-80	FF B1 (-79 dBm)	-79 dBm
-90	1111111110100110 (xFFA6)	-90	FF A7 (-89 dBm)	-89 dBm

6.3.4.4 Software Version

Verify the WRM reports the software version. This command is only available through the Telnet interface.

Table 6-95. Software Version Telnet Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialize.	1. Use the test setup shown in Figure 6-1. Single WRM Test Setup. 2. Execute Telnet initialization procedure in Section 6.2.3.1.	N/A	N/A
1.	Verify the WRM response to the *version* command.	1. Use the API Tester to send the *version* Telnet command and verify the WRM response.	API Tester displays response: *AP software: 3.1.0.358* *WRM software: x.x* *mmm dd yyy, hh:mm:ss*	AP software: 3.1.0.358 WRM software: 1.9 Jul 16 2004, 11:28:11

6.4 WRM Functional Specification Tests

This section specifies tests to verify requirements in the WRM Functional Specification that were not verified during the WRM Interface Specification Tests.

6.4.1 Power-Up Initialization

Upon power-up, verify the WRM initializes to the last saved configuration. The WRM saves its configuration whenever it is commanded to WAVEdefault parameters (through either a Telnet command or IP command) or upon a Telnet command changing a parameter value.

Table 6-96. Power-Up Initialization Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialize.	1. Use the test setup shown in Figure 6-1. Single WRM Test Setup. 2. Execute Telnet initialization procedure in Section 6.2.3.1.	N/A	N/A
1.	Verify power up initialization to WAVE default parameters.	1. Cycle power on the WRM. 2. Use the API Tester to send the *get config* Telnet command.	API Tester displays configuration data including default parameter values listed in Table 6-3.	Configuration data matches default values listed in the table.
	Modify the configuration using Telnet commands.	3. Use API Tester to send the following commands and display WRM response: • *set unitmode RSU* • *set servicemode private* • *set antenna 1* • *set antenna1comp 2* • *set antenna2comp –4* • *set fastchannel 52* • *set bandwidth 10* • *set rate 12* • *set fragmentthreshold 300* • *set rtsthreshold 400* • *set power 10*	API Tester displays WRM responses echoing new settings.	API Tester echoes Telnet command settings.
	Verify power up initialization to modified parameters.	4. Cycle power on the WRM. 5. Use the API Tester to send the *get config* Telnet command.	API Tester displays WRM responses echoing step 3 settings.	API Tester reports all parameter values matching the values set in step 3.
	Set WRM to default parameters using a Telnet command.	6. Use the API Tester to send the *set WAVEdefault* command and verify response.	API Tester displays response: *WAVEdefault*. WRM reboots.	WRM rebooted
	Verify power up to default parameters	7. Cycle power on the WRM. 8. Use the API Tester to send the *get config* Telnet command.	API Tester displays configuration data including default parameter values listed in Table 6-3.	Configuration data matches default values listed in the table.
	Modify the configuration using IP config commands.	9. Send the same set of commands as in step 3.	See step 3.	API Tester displays IP configuration parameter settings.
	Set WRM to default parameters using an IP Config command.	10. Use the API Tester to send an IP default configuration request.	N/A	N/A

#	Description	Test Steps	Expected Results	Actual Results
	Verify power up initialization to default parameters.	11. Use the API to get the WRM configuration using an IP command.	API Tester displays WRM configuration showing default parameter values listed in Table 6-3.	Configuration data matches default values listed in the table.

6.4.2 MAC Address

Verify when the WRM is operating in RSU mode, it uses the stored MAC address. Verify when the WRM is operating in OBU mode, it generates a random MAC address when it powers up. The MAC address may only be obtained through the IP Configuration interface.

Table 6-97. MAC Address Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization.	1. Use the test setup shown in Figure 6-1. Single WRM Test Setup. 2. Execute IP initialization procedure in Section 0.	N/A	N/A
1.	Get MAC address (WRM is in OBU mode).	1. Use the API Tester to get the WRM configuration. 2. Use Ethereal to verify the WCO MAC address.	WRM sends WCO with MAC address (Word 4, bits 00-31, and Word 5, bits 00-15)	(W4) DA 21 3F CF (W5) 9D 5D 00 00
		3. Use the API Tester to verify the WRM configuration.	API Tester displays MAC address equivalent to WCO contents.	API Tester displays MAC Address: DA:21:3F:CF:9D:5D
	Verify WRM generates new address on subsequent power up.	4. Cycle power on the WRM. 5. Use the API Tester to get the WRM configuration and display the MAC address.	API Tester displays a different MAC address than in step 3.	API Tester displays MAC Address: B2:1B:26:90:6C:5A
2.	Configure WRM to RSU mode, cycle power, and get MAC address.	1. Use the API Tester to send the *set unitmode RSU* Telnet command. 2. Cycle power on the WRM. 3. Use the API Tester to get the WRM configuration. 4. Use Ethereal to verify the WCO MAC address.	WRM sends WCO with MAC address (Word 4, bits 00-31, and Word 5, bits 00-15)	(W4) 00 03 7F BF (W5) 0D F4 00 00
		5. Use the API Tester to verify the WRM configuration.	API Tester displays MAC address equivalent to WCO contents.	API Tester displays MAC Address: 00:03:7F:BF:0D:F4

#	Description	Test Steps	Expected Results	Actual Results
	Verify WRM uses same MAC address on subsequent power up.	6. Cycle power on the WRM. 7. Use the API Tester to get the WRM configuration and display the MAC address.	API Tester displays the same MAC address as in step 5.	API Tester displays MAC Address: 00:03:7F:BF:0D:F4

6.4.3 802.11 Management Frames

Verify the WRM does not transmit any IEEE 802.11 [3] management frames. Upon receiving a management frame, verify the WRM acknowledges the frame but does not take action based on its contents.

Table 6-98. 802.11 Management Frames Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization.	1. Use the test setup shown in Figure 6-3. WRM with Spectrum Analyzer Test Setup. 2. Execute IP initialization procedure in Section 0.	N/A	N/A
1.	Verify WRM does not transmit any IEEE 802.11 management frames.	1. Use spectrum analyzer to verify WRM is not transmitting.	Spectrum analyzer displays flat line, indicating no data is being transmitted.	Spectrum analyzer does not indicate any data transmissions.
		2. Use the API Tester to continuously broadcast packets. 3. Use the spectrum analyzer to verify the WRM transmissions.	Spectrum analyzer displays wave patterns indicating data is being transmitted.	Spectrum analyzer displays patterns indicating data is being transmitted.
		4. Use the API Tester to stop packet broadcast. 5. Use the spectrum analyzer to verify the WRM is not transmitting.	Spectrum analyzer displays flat line, indicating no data is being transmitted.	Spectrum analyzer does not indicate any data transmissions.

6.4.4 802.11 DATA Frames

Verify the WRM constructs MAC frames in accordance with IEEE 802.11. The MAC frames contains address fields which must be set as follows:

1. Basic Service Set Identification (BSSID) – this field shall be set to all 0s.

2. Source Address – this field shall be set to the WRM MAC address.
3. Destination Address – Broadcast MAC address or destination address provided by HD.

The WRM shall always set the Power Management, More Data, and Wired Equivalent Privacy (WEP) fields to 0. For data frames, verify the subtype is set to data.

Table 6-99. Data Tx/Rx Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization.	1. Use the test setup shown in Figure 6-8. Dual WRMs. 2. Execute IP initialization procedure in Section 0 on both HD/WRM setups.	N/A	N/A
1.	Get HD-2 MAC address.	1. Use the HD-2 API Tester to get the local MAC address.	API Tester displays local MAC address.	HD-2 MAC Address: BE:C3:65:83:10:A5
	Transmit and receive data frames.	2. Use the HD-2 API Tester to transmit one packet with PBP control with a broadcast destination address. 3. Use the HD-1 Ethereal to verify the WRXO MAC Header field.	WRM sends WRXO with MAC Header field (see 802.11, Chapter for format). Verify BSSID is all 0s, Source Address is the HD-2 MAC address, Destination Address is the Broadcast MAC address. Verify the Power Management, More Data, and WEP fields are 0. Verify the subtype is data (0000)	BSSID: 00 00 00 00 00 00 Source Address: BE:C3:65:83:10:A5 Destination Address: FF FF FF FF FF FF Power Mgmt = 0 More Data = 0 WEP = 0 Subtype = 0000
		4. Use the HD-2 API Tester to transmit one packet with PBP control with a unicast destination address. 5. Use the HD-1 Ethereal to verify the WRXO MAC Header field.	WRM sends WRXO with MAC Header field values the same as in step 3 except the Destination Address is the specified unicast address.	Destination Address: 5A:39:8D:31:EA:18

6.4.5 WRM Reconfiguration Time

Verify the WRM reconfigures to new settings, other than wireless mode changes, within 5 ms.

Table 6-100. WRM Reconfiguration Time Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization.	1. Use the test setup shown in Figure 6-6. WRM with Vector Signal Analyzer Test Setup. 2. Execute IP initialization procedure in Section 6.3.1.2 on both HD/WRM setups.	N/A	N/A
1.	Set up WRM configurations and VSA, and start recording data transmissions on the VSA.	1. Use API Tester to configure WRM Configuration #1 to channel 174, 6Mbps data rate, 20dBm Tx power, and to transmit 1000 byte data packets 5 times every 10ms. 2. Use API Tester to configure WRM Configuration #2 to channel 175, 12Mbps data rate, 10dBm Tx power, and to transmit 1000 byte data packets 10 times every 10ms. 3. Use API Tester to configure WRM Configuration #3 to channel 176, 6Mbps data rate, 20dBm Tx power, and to transmit 1000 byte data packets 5 times every 10ms. 4. Setup the VSA to display at least 30ms of time domain information, including WRM channel, Tx power, and data rate. Use the API Tester to broadcast continuously by repeatedly cycling through the above WRM configurations. .	VSA displays data packet transmissions.	VSA displays packet transmissions.

#	Description	Test Steps	Expected Results	Actual Results
	Verify the WRM reconfigures within 5ms.	5. Watch on the VSA for indication that the WRM has changed channel, Tx power, and data rate, switching from WRM configuration #1 to WRM configuration #2. 6. Pause the real-time display on the VSA to make a time measurement. 7. Use the VSA to measure the time between the stop and restart of data as recorded on the VSA.	The VSA indicates that the time between stop and restart of data is 5ms or less.	2.8ms reconfiguration time measured for transition from configuration 1-> configuration 2. 3.3ms reconfiguration time measured for transition from configuration 2 -> configuration 3. 3.2ms reconfiguration time measured for transition from configuration 3 -> configuration 1.
	Verify new WRM configuration.	8. Use the VSA to measure the channel value at the time data stopped and at the time data restarted.	Within this 5ms time period the VSA displays a change in channel from 174 to 175.	Frequency changed from 5870 MHz (IEEE 174) to 5875 MHz (IEEE 175) in 2.8ms.
		9. Use the VSA to measure the Tx power level at the time data stopped and at the time data restarted.	Within this 5ms time period the VSA displays a change in Tx power from 20dBm to 10dBm.	Tx power changed from 20dBm to 10dBm in 2.8ms.
		10. Use the VSA to measure the data rate at the time data stopped and at the time data restarted.	Within this 5ms time period the VSA displays a change in data rate from 6Mbps to 12Mbps. *Note: this test result will depend on the ability of the VSA to demodulate the first packet following the channel, power, and data rate change.*	Data rate changed from 6Mbps to 12Mbps in 2.8ms.

6.5 WRM Network Tests

6.5.1 Single Transmitter with Multiple Receivers

6.5.1.1 Broadcast Addressing

Single-Channel Operation Test

This test verifies single-channel operation with broadcast messages.

- Four WRMs operating on the same channel:
  - One WRM broadcasting 50 byte data bursts every 100ms.
  - Three WRMs set up to receive.
- Test operator verifies data is received at all three receiving stations.

Table 6-101. Broadcast Addressing Single Channel Operation Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization.	1. Configure four test setups, each one configured as shown in Figure 6-1. Single WRM Test Setup. 2. Execute IP initialization procedure in Section 6.2.3.2 on all HD/WRM setups.	N/A	N/A
1.	Verify WRMs receive the data	1. Use HD-1 API Tester to repeatedly broadcast a 50-byte data packet every 100 ms w/o PBP control. 2. Use the HD-2, HD-3, and HD-4 API Testers to verify data is being received at each WRM.	API Testers for HD-2, HD-3, and HD-4 display received data packet information.	HD-2, 3, & 4 report data packets received.
		3. Allow packet broadcasting to continue for 60 seconds. 4. Use HD-1 API Tester to stop packet broadcast.	API Testers for HD-2, HD-3, and HD-4 stop displaying received data packet information, and indicate receipt of ~600 packets (or 10 packets times the # of seconds the test ran).	HD-1 transmitted 603 packets. HD-2 received 603 packets. HD-3 received 603 packets. HD-4 received 603 packets.

Multi-Channel Operation Test

This test verifies multi-channel operation and transmitter channel switching with broadcast messages.

- One station broadcasting data bursts and changing to one of three channels every 5 seconds.
- Three stations set up to receive on three unique channels.
- Test operator verifies data is received on each receiving station only on the corresponding channel.

Table 6-102. Broadcast Addressing Multi-Channel Operation Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization.	1. Configure four test setups, each one configured as shown in Figure 6-1. Single WRM Test Setup. 2. Execute IP initialization procedure in Section 6.2.3.2 on all HD/WRM setups.	N/A	N/A
1.	Tune WRMs to test channels.	1. Use HD-2 API Tester to set the WRM configuration with the channel of 172. 2. Use HD-3 API Tester to set the WRM configuration with the channel of 176. 3. Use HD-4 API Tester to set the WRM configuration with the channel of 181. 4. Use the API Testers to confirm the WRM configurations.	Each API Tester confirms the corresponding WRM is set to the correct channel.	HD-2 channel = 172. HD-3 channel = 176. HD-4 channel = 181.
	Set up PBP configurations.	5. Use HD-1 API Tester to create three PBP configurations: • One configuration to broadcast a unique 50-byte data packet on channel 172, • A second configuration to broadcast a unique 50-byte data packet on channel 176, • A third configuration to broadcast a unique 50-byte data packet on channel 181.	N/A	N/A
	Broadcast data bursts.	6. Use HD-1 API Tester to repeatedly cycle through the three PBP configurations every 1 second.	N/A	N/A

#	Description	Test Steps	Expected Results	Actual Results
	Verify WRMs receive the data	7. Use the HD-2, HD-3, and HD-4 API Testers to verify the data received at each WRM is correct for the corresponding receive channel.	API Testers for HD-2, HD-3, and HD-4 only display received data packet information corresponding to the channel to which they are tuned.	API Testers on each HD only report receiving data packets on the channel they are tuned to.
		8. Allow PBP transmissions continue cycling for 60 seconds. 9. Use HD-1 API Tester to stop PBP Transmissions.	API Testers for HD-2, HD-3, and HD-4 stop displaying received data packet information, and indicate receipt of ~20 packets (or 1 packet for each 3 seconds the test was run).	Each HD reported receiving 20 packets.

Directed Addressing

Single-Channel Operation Test

This test verifies single-channel operation with directed (unicast) destination MAC addresses.

- One station transmitting alternate data bursts to specific MAC addresses every 5 seconds.
- Three stations with unique MAC addresses set up to receive.
- Test operator verifies appropriately addressed data is received at the receiving stations.

Table 6-103. Directed Addressing Single-Channel Operation Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization.	1. Configure four test setups, each one configured as shown in Figure 6-1. Single WRM Test Setup. 2. Execute IP initialization procedure in Section 6.2.3.2 on all HD/WRM setups.	N/A	N/A
1.	Get MAC addresses.	1. Use the HD-2, HD-3, and HD-4 API Testers to get the MAC address of each corresponding WRM.	API Testers report the corresponding MAC addresses.	HD-2 MAC Address: 9A:2B:E2:49:7E:77 HD-3 MAC Address: 4A:CD:15:E4:B9:46 HD-4 MAC Address: AA:1F:A4:17:A8:84
	Set up PBP configurations	2. Use HD-1 API Tester to create three PBP configurations: • One configuration to transmit a unique 50-byte data packet to MAC address of WRM-2, • A second configuration to transmit a unique 50-byte data packet to MAC address of WRM-3, • A third configuration to transmit a unique 50-byte data packet to MAC address of WRM-4.	N/A	N/A
	Transmit data bursts.	3. Use HD-1 API Tester to repeatedly cycle through the three PBP configurations at 100ms intervals.	N/A	N/A
	Verify WRMs receive the data	4. Use the HD-2, HD-3, and HD-4 API Testers to verify the data being received at each WRM is correct for the corresponding MAC address.	API Testers for HD-2, HD-3, and HD-4 only display received data packet information corresponding to their MAC address.	API Tester on each HD reported receiving only data specifically addressed to their respective MAC addresses.

#	Description	Test Steps	Expected Results	Actual Results
		5. Allow packet transmissions to continue for 60 seconds. 6. Use HD-1 API Tester to stop packet transmissions.	API Testers for HD-2, HD-3, and HD-4 stop displaying received data packet information, and indicate receipt of ~200 packets (or 10 packets for each 3 seconds the test was run).	HD-1 transmitted 694 packets in ~69 seconds. HD-2 received 232 packets. HD-3 received 231 packets. HD-4 received 231 packets.

Multi-Channel Operation Test

This test verifies multi-channel operation and channel switching with directed (unicast) destination MAC addresses.

- One station transmitting data bursts to specific MAC addresses on specific channels, switching channels every 5 seconds.
- Three stations with unique MAC addresses set up to receive on three unique channels.
- Test operator verifies appropriately addressed data is received on the correct channel at the receiving stations.

Table 6-104. Directed Addressing Multi-Channel Operation Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization.	1. Configure four test setups, each one configured as shown in Figure 6-1. Single WRM Test Setup. 2. Execute IP initialization procedure in Section 6.2.3.2 on all HD/WRM setups.	N/A	N/A
1.	Get MAC addresses.	1. Use the HD-2, HD-3, and HD-4 API Testers to get the MAC address of each corresponding WRM.	API Testers report the corresponding MAC addresses.	HD-2 MAC Address: 9A:2B:E2:49:7E:77 HD-3 MAC Address: 4A:CD:15:E4:B9:46 HD-4 MAC Address: AA:1F:A4:17:A8:84

#	Description	Test Steps	Expected Results	Actual Results
	Tune WRMs to test channels.	2. Use HD-2 API Tester to set the WRM configuration with the channel of 172. 3. Use HD-3 API Tester to set the WRM configuration with the channel of 176. 4. Use HD-4 API Tester to set the WRM configuration with the channel of 181. 5. Use the API Testers to confirm the WRM configurations	Each API Tester confirms the corresponding WRM is set to the correct channel.	HD-2 channel = 172. HD-3 channel = 176. HD-4 channel = 181.
	Set up PBP configurations	6. Use HD-1 API Tester to create three PBP configurations: • one configuration to transmit a unique 50-byte data packet, on channel 172, at 20dBm power level, to MAC address of WRM-2, • a second configuration to transmit a unique 50-byte data packet, on channel 176, at 15 dBm power level, to MAC address of WRM-3, • a third configuration to transmit a unique 50-byte data packet, on channel 181, at 10 dBm power level, to MAC address of WRM-4.	N/A	N/A
	Transmit data bursts.	7. Use HD-1 API Tester to repeatedly cycle through the three PBP configurations at 100ms intervals.	N/A	N/A
	Verify WRMs receive the data	8. Use the HD-2, HD-3, and HD-4 API Testers to verify the data being received at each WRM is correct for the corresponding MAC address and channel.	API Testers for HD-2, HD-3, and HD-4 only display received data packet information corresponding to their MAC address and channel.	Data received on HD-2, 3, & 4 is correct for their respective MAC addresses.

#	Description	Test Steps	Expected Results	Actual Results
		9. Allow PBP transmissions to continue for 60 seconds. 10. Use HD-1 API Tester to stop PBP transmissions.	API Testers for HD-2, HD-3, and HD-4 stop displaying received data packet information, and indicate receipt of ~200 packets (or 10 packets for each 3 seconds the test was run).	HD-1 transmitted 600 packets in 60 seconds. HD-2 received 200 packets. HD-3 received 20 packets. HD-4 received 20 packets.

6.5.2 Multiple Transmitters with Multiple Receivers Test

This test verifies channel contention situations, with multiple transmitters and receivers operating on the same channel.

- Six WRMs operating on the same channel:
  - Three WRMs using directed MAC addressing to transmit data to three different receivers.
  - Three WRMs with unique MAC addresses set up to receive.
- Test operator verifies appropriately addressed data is received at the receiving stations.

Table 6-105. Multiple Transmitters with Multiple Receivers Test

#	Description	Test Steps	Expected Results	Actual Results
	Initialization.	1. Configure six test setups, each one configured as shown in Figure 6-1. Single WRM Test Setup. 2. Execute IP initialization procedure in Section 6.2.3.2 on all HD/WRM setups.	N/A	N/A
1.	Get MAC addresses.	1. Use the HD-4, HD-5, and HD-6 API Testers to get the MAC address of each corresponding WRM.	API Testers report the corresponding MAC addresses.	HD-4 MAC Address: 9A:2B:E2:49:7E:77 HD-5 MAC Address: 4A:CD:15:E4:B9:46 HD-6 MAC Address: AA:1F:A4:17:A8:84

#	Description	Test Steps	Expected Results	Actual Results
	Set up PBP configurations	2. Use HD-1 API Tester to create one PBP configuration to transmit a unique 1000-byte data packet 40 times every 100ms on channel 178 to MAC address of WRM-4. 3. Use HD-2 API Tester to create one PBP configuration to transmit a unique 1000-byte data packet 5 times every 100ms on channel 178 to MAC address of WRM-5. 4. Use HD-3 API Tester to create one PBP configuration to transmit a unique 1000-byte data packet 5 times every 100ms on channel 178 to MAC address of WRM-6.	N/A	N/A
	Transmit data bursts.	5. Use HD-1, HD-2, and HD-3 API Testers to repeatedly transmit their PBP configurations.	N/A	N/A
	Verify WRMs receive the data	6. Use the HD-4, HD-5, and HD-6 API Testers to verify the data being received at each WRM is correct for the corresponding MAC address.	API Testers for HD-4, HD-5, and HD-6 only display received data packet information corresponding to their MAC address.	HD-4, 5, & 6 display only receive data corresponding to their MAC addresses.
		7. Allow PBP transmissions to continue for 180 seconds. 8. Use HD-1, HD-2, and HD-3 API Testers to stop PBP transmissions.	API Testers for HD-4, HD-5, and HD-6 stop displaying received data packet information.	HD-4, 5, & 6 stop reporting received data packets.
		9. Use the HD-5 and HD-6 API Testers to verify data received at each WRM.	API Testers for HD-5 and HD-6 indicate receipt of ~150 packets (or 1 packet for each 15 seconds the test was run).	HD-1 transmitted 100560 packets. HD-4 received 64413 packets. HD-2 transmitted 12580 packets. HD-5 received 12579 packets. HD-3 transmitted 10530 packets. HD-6 received 10530 packets.

6.6 Requirement/Test Cross-Reference Matrix

Section Number	Requirement	Test Procedure
3.3.1	The WRM shall support the commands and responses described in the WRM Interface Specification.	6.3
3.3.1	Upon receiving a command to change to a new wireless mode followed by a reboot command, the WRM shall begin operation in the new mode within 10 seconds after receiving the reboot command.	6.3.2.1
3.3.1	Upon receiving a command to change any parameter other than wireless mode, the WRM shall reconfigure to the new setting within 5 ms.	6.4.5
3.3.2.1	The WRM shall support transmit and receive on a single antenna (antenna 1 or 2), and shall also support an antenna "best" mode. The antenna configuration is settable by the HD.	6.3.3.1
3.3.2.2	The WRM shall be able to tune to any WAVE channel as specified by ASTM E2213-03, and any US 802.11a channel as specified by IEEE 802.11a.	6.3.3.5
3.3.2.2	For WAVE channels, the WRM shall support operation at the bandwidth (10 or 20 MHz) specified by ASTM E2213-03.	6.3.3.5
3.3.2.2	For 802.11a channels, the WRM radio shall support operation with either a 10 or 20 MHz bandwidth.	6.3.3.4
3.3.2.2	The WRM shall support all data rates specified by ASTM E2213-03 for channels operating with a 10 MHz bandwidth.	6.3.3.8
3.3.2.2	The WRM shall support all data rates specified by IEEE 802.11a for channels operating with a 20 MHz bandwidth.	6.3.3.8
3.3.2.2	The channel, channel bandwidth, and data rate are settable by the HD.	6.3.3.4 6.3.3.5 6.3.3.8
3.3.2.3	The WRM shall support transmitting at an HD-settable power level up to nominally 20 dBm or higher if available.	6.3.3.7
3.3.2.3	For WAVE channels, the WRM shall limit the transmit power at the SMA connector so the maximum allowable level at the antenna input, as specified by ASTM E2213-03, will not be exceeded.	6.3.3.7.2
3.3.3.1	Upon power-up, the WRM shall initialize to the last stored configuration. The WRM will save its configuration approximately every minute if any changes have occurred.	6.4.1
3.3.2.2	When the WRM is operating in RSU mode, it shall use the last stored MAC address. When the WRM is operating in OBU mode, it shall generate a random MAC address when it powers up and whenever it is commanded by the HD to switch from RSU to OBU mode.	6.4.2

Section Number	Requirement	Test Procedure
3.3.3.3	The WRM shall construct MAC frames in accordance with IEEE 802.11. The MAC frames contain address fields which shall be set as follows: 1. Basic Service Set Identification (BSSID) – shall be set to all 0s. 2. Source Address – shall be set to the WRM MAC address. 3. Destination Address – Broadcast MAC address. The WRM shall always set the Power Management, More Data, and Wired Equivalent Privacy (WEP) fields to 0.	6.4.4
3.3.3.3	The WRM shall perform fragmentation as required to limit the size of any MAC frames to less than or equal to the MAC fragmentation threshold.	6.3.3.6
3.3.3.4	The WRM shall not transmit any IEEE 802.11 management frames. Upon receiving a management frame, the WRM shall acknowledge the frame but not take action based on its contents.	6.4.3
3.3.3.5	On non-control channels, the WRM shall support the use of 802.11 RTS, CTS, and ACK control frames. The WRM shall not transmit any other type of control frame.	3.3.9
3.3.3.5	When transmitting on a non-control channel, the WRM shall send an RTS frame only if the MAC frame length exceeds the RTS/CTS threshold.	6.3.3.9
3.3.3.6	The WRM shall support the use of 802.11 data frames with the subtype data. The WRM shall not transmit any other type of data frame.	6.4.4

7 ACCEPTANCE TEST REPORT

This document summarizes the results of executing the WAVE Radio Module (WRM) Acceptance Test Plan (ATP) (Chapter 6) for the WRM delivered in accordance with the VSC Project: Preliminary Requirements for Second Generation WAVE Radio Module [Section 1.2].

7.1 Scope

Denso conducted all tests specified in the ATP and recorded the results to complete the ATP document. The completed ATP comprises Chapter 6 in this document.

7.2 Test Equipment

The following test equipment was used to complete the ATP:

Description	Model Number
Attenuators	Various values, including 10 dB, 20 dB, 30 dB, and 50 dB fixed attenuators, and a step attenuator.
Power Meter	Gigatronics 8651A meter with 80701 sensor head.
Spectrum Analyzer	HP 8563E
Vector Signal Analyzer	HP 4352B

7.3 ATP Result Summary

Denso conducted all tests as outlined in the ATP on July 16-20, with the exception of the fragment threshold test in Section 3.3.6. The WRM does not currently support fragmentation in WAVE mode. All tests passed, with the exception of some test steps conducted within the Antenna Configuration and Power tests. The following table presents a summary of the ATP Test Results.

Paragraph	Test	Results		
		Telnet	IP Configuration	PbP
6.3.1	WAVEdefault	Pass	Pass	N/A
6.3.2.1	Wireless Mode	Pass	N/A	N/A
6.3.2.2	Service Mode	Pass	Pass	Pass
6.3.2.3	Unit Mode	Pass	Pass	Pass
6.3.3.1	Antenna Configuration	Fail (See Comment 1)	Fail (See Comment 1)	Fail (See Comment 1)

Paragraph	Test	Results		
		Telnet	IP Configuration	PbP
6.3.3.2	Antenna 1 Compensation Factor	Pass	Pass	N/A
6.3.3.3	Antenna 2 Compensation Factor	Pass	Pass	N/A
6.3.3.4	Bandwidth	Pass	Pass	Pass
6.3.3.5	Fastchannel	Pass		
6.3.3.6	Fragmentation			
6.3.3.7	Power	Fail (See Comment 2)	Fail (See Comment 2)	Fail (See Comment 2)
6.3.3.8	Data Rate	Pass	Pass	Pass
6.3.3.9	RTS Threshold	Pass	Pass	Pass
6.3.4.1	Configuration Parameters	Pass	Pass	N/A
6.3.4.2	Hardware Version	Pass	N/A	N/A
6.3.4.3	RSSI	Pass	N/A	Pass
6.3.4.4	Software Version	Pass	N/A	N/A
6.4.1	Power-up Initialization	Pass	Pass	N/A
6.4.2	MAC Address	Pass		
6.4.3	802.11 Management Frames	Pass		
6.4.4	802.11 Data Frames	Pass		
6.4.5	WRM Reconfiguration Time	Pass		
6.5.1.1	Single Transmitter with Multiple Receiver – Broadcast Addressing	Pass		
6.5.1.2	Single Transmitter with Multiple Receiver – Directed Addressing	Pass		
6.5.2	Multiple Transmitters with Multiple Receivers	Pass		

Test Result Comments:

1. When antenna 1 or antenna 2 is selected, most packets are received on the selected antenna, but the API Tester reports some packets also being received on the non-selected antenna. See 7.3.1 for more details.
2. Some output power measurements were outside the +/- 1dB margin. See 7.3.2 for more details.

7.3.1 Antenna Configuration Tests

Subsequent to the ATP, extended Antenna Configuration testing was performed to more accurately quantify the ratio of packets received on the non-selected antenna to those received on the selected antenna. These tests were run with broadcasted packets (no acknowledgements) and strong RSSI. In all cases greater than 98% of the transmitted packets were received.

7.3.1.1 No Attenuation on Selected Antenna

Testing was performed with no attenuation between the WRM SMA connectors and the antennas. When antenna 1 was selected, 99% of the received packets were correctly received on antenna 1, with the remaining 1% received on antenna 2. When antenna 2 was selected, 97.5% of the received packets were correctly received on antenna 2, with the remaining 2.5% received on antenna 1.

7.3.1.2 50 dB Attenuator on Selected Antenna

Testing was performed with 50 dB of attenuation between the WRM SMA connector for the selected antenna and the antenna. When antenna 1 was selected, 93% of the received packets were correctly received on antenna 1, with the remaining 7% received on antenna 2. When antenna 2 was selected, 98% of the received packets were correctly received on antenna 2, with the remaining 2% received on antenna 1.

7.3.1.3 No Antenna on Selected Antenna

Testing was performed with only a 50Ω load (no antenna) attached to the selected antenna. When antenna 1 was selected, 96% of the received packets were correctly received on antenna 1, with the remaining 4% received on antenna 2. When antenna 2 was selected, 95% of the received packets were correctly received on antenna 2, with the remaining 5% received on antenna 1.

7.3.1.4 No Antenna on Non-Selected Antenna

Testing was performed with only a 50Ω load (no antenna) attached to the non-selected antenna. When antenna 1 was selected, 97% of the received packets were correctly received on antenna 1, with the remaining 3% received on antenna 2. When antenna 2 was selected, 98% of the received packets were correctly received on antenna 2, with the remaining 2% received on antenna 1.

7.3.2 Power Tests

All output power measurements outside the proposed +/- 1dB margin are highlighted in the completed ATP. For the worst cases, power measurements fell outside the +/- 1dB margin by an additional +1.3/-0.6 dB.

The WRM unit used for performing the ATP Power Tests consistently produced between 0.5 and 1 dB lower output power levels when transmitting on antenna 2 compared to antenna 1. In general, antenna 2 posted better output power results than antenna 1.

Power Limiting Test results showed the WRM consistently and appropriately limited the transmit power. However, due to the power setting issues described above, the measured power for some settings was outside the +/- 1dB margin.

7.4 Software Issues Discovered While Testing

While executing the ATP, the software issues presented in this section were identified. All problems were reported to software developers, and corrections were implemented. The software fixes were verified by re-running appropriate sections of the ATP. The ATP includes the rerun test results.

Denso maintains the software in a configuration management tool, labels all builds used in formal tests, and tracks all changes. All API Tester issues were discovered in the build labeled VSCC version 0.1 and corrected in VSCC version 0.2. The WRM issue was discovered in the build labeled VSCC version 0.1 and corrected in VSCC version 0.2.

7.4.1 API Tester Issues

7.4.1.1 Bandwidth setting could be changed while WAVE channel is selected

The API Tester allowed the user to change the bandwidth setting while a WAVE channel was selected. Since the bandwidth setting only applies to 802.11a channels, the API Tester should not allow the user to change the bandwidth setting when a WAVE channel is selected.

The API Tester was modified to disable bandwidth changes when a WAVE channel is selected.

7.4.1.2 API Tester changed 802.11a Bandwidth setting without user issuing the change

The API Tester used the 802.11a Bandwidth field to report the selected WAVE channel's bandwidth. When changing from a 10 MHz WAVE channel to an 802.11a channel, the 10 MHz bandwidth setting was always applied to the 802.11a channel, regardless of the previous 802.11a Bandwidth setting.

The API Tester was modified to disable bandwidth reporting when a WAVE channel is selected, and only display the last 802.11a Bandwidth setting.

7.4.1.3 Telnet login not consistently successful on power up or following reset

Following a Telnet WAVEdefault command, API Tester occasionally reported "WRM Get Configuration Communication Error or not in WAVE mode". Each time this error message was displayed by the API Tester, the user issued a Telnet Config Command. The API Tester then reported incorrect login in the Telnet window.

The API Tester was modified to detect login failures on the Telnet interface and to retry the Telnet login.

7.4.1.4 WRM configuration not consistently retrieved on power up or following reset

Following an IP Reset WAVE Default command, API Tester occasionally reported "WRM Get Configuration Communication Error or not in WAVE mode". Each time this error message was displayed by the API Tester, the user issued an IP Get Current Configuration Command. The API Tester then reported the current configuration without reporting any errors.

This issue was the result of the API Tester trying to establish communication with the WRM before the WRM completed power up or reset. The API Tester was modified to detect errors and retry when establishing communication with the WRM.

7.4.2 WRM Issue

7.4.2.1 IP Reset WAVE Default did not consistently reset WRM parameters to defaults

While running the ATP, the IP Configuration WAVE default command did not always reset the parameters to the default settings.

Under certain circumstances the WRM software did not recognize that parameters had been changed from the default configuration, so the parameter values were not being reset to the default values. The WRM software was modified to correct this issue.

A-1 TERMS, ACRONYMS, AND ABBREVIATIONS

Acronym	Term
AC	Alternating Current
ACK	Acknowledgement
ADC	Analog-to-Digital Converter
AES	Advanced Encryption Standard
ANSI	American National Standards Institute
ANT	Antenna
AP	Access Point
API	Application Programming Interface
AR	Atheros
ASTM	American Society for Testing and Materials
ATP	Acceptance Test Plan
BDA	Bi-Directional Amplifier
BPSK	Binary Phase Shift Keying
BSSID	Basic Service Set Identification
BW	Bandwidth
CFR	Code of Federal Regulations
CLA	Cigarette Lighter Adapter
CLI	Command Line Interface
CSMA/CA	Carrier Sense Multiple Access/Collision Avoidance
CTS	Clear to Send
DAC	Digital-to-Analog Converter
dB	Decibel
dBi	Decibel Isotropic
dBm	Decibel Milliwatts
DC	Direct Current
DSRC	Dedicated Short Range Communications
EIRP	Equivalent Isotropically Radiated Power
EJTAG	Enhanced Joint Test Action Group (a standard defined by MIPS Technologies)
EVM	Error Vector Magnitude
FCC	Federal Communications Commission
FEC	Forward Error Correction
FIPS	Federal Information Processing Standard
FLASH	A type of nonvolatile memory that can be erased and reprogrammed
GHz	Gigahertz
GPIO	General Purpose Input Output
GUI	Graphical User Interface

HD	Host Device
Hz	Hertz
ICE	In-Circuit Emulator
IEEE	Institute of Electrical and Electronics Engineers
IHL	IP Header Length
IP	Internet Protocol
LAN	Local Area Network
LED	Light Emitting Diode
MAC	Medium Access Control
Mbps	Megabits per Second
MHz	Megahertz
MII	Media Independent Interface
MIPS	Reference to MIPS Technologies
N/A	Not Applicable
N/A	Not Applicable
NDA	Non-Disclosure Agreement
ns	Nanoseconds
OBU	On Board Unit
OFDM	Orthogonal Frequency Division Multiplexing
OS	Operating System
PBP	Packet-by-Packet
PCB	Printed Circuit Board
PCF	Point Control Function
PCI	Peripheral Component Interconnect
PER	Packet Error Rate
PHY	Physical Layer
ppm	Parts per Million
QAM	Quadrature Amplitude Modulation
QPSK	Quaternary Phase Shift Keying
RF	Radio Frequency
RFC	Request for Comment
RMS	Root Mean Square
RS-232	A mature serial data interface standard
RSSI	Received Signal Strength Indicator
RSU	Road Side Unit
RSV	Reserved
RTOS	Real-Time Operating System
RTS	Request to Send
RX	Receiver

Rx	Receive
SDRAM	Synchronous Dynamic Random Access Memory
SM	Service Mode
SMA	Subminiature Version A (a high frequency RF connector)
SOW	Statement Of Work
SSID	Service Set ID
SW	Software
TBD	To Be Determined
TCP	Transport Control Protocol
TKIP	Temporal Key Integrity Protocol
TX	Transmitter
Tx	Transmit
UART	Universal Asynchronous Receiver-Transmitter
UM	Unit Mode
UNII	Unlicensed National Information Infrastructure
VSA	Vector Signal Analyzer
VSC	Vehicle Safety Communications
VSCC	Vehicle Safety Communications Consortium
WAVE	Wireless Access in Vehicular Environments
WCO	WAVE Configuration Option
WCRO	WAVE Configuration Request Option
WEP	Wired Equivalent Privacy (original 802.11 data encryption standard)
WRM	WAVE Radio Module
WRXO	WAVE Rx Option
WTXO	WAVE Tx Option

A-2 REFERENCES

[1] ASTM E2213-03 Standard Specification for Telecommunications and Information Exchange Between Roadside and Vehicle Systems – 5 GHz Band Dedicated Short Range Communications (DSRC) Medium Access Control (MAC) and Physical Layer (PHY) Specifications.

[2] IEEE 802.11a, 1999 Edition, Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications. High-speed Physical Layer in the 5 GHz band.

[3] ANSI/IEEE 802.11 - 1999 (Reaff 2003), Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications.

[4] CFR Title 47—Telecommunication, CHAPTER I--FEDERAL COMMUNICATIONS COMMISSION , PART 90--PRIVATE LAND MOBILE RADIO SERVICES

[5] Atheros AR5002AP-X Product Sheet, not dated

[6] Atheros AR5002 Family Chipset Product Sheet, not dated

[7] Hirose U.FL Series Miniature RF Coaxial Connectors (and cables), dated January 2004

[8] CUI Inc. DPS050240-P5 120V/5V AC-DC Power Converter, dated April 2002

[9] Internet Engineering Task Force RFC 854 Telnet Protocol Specification, dated May 1983.

[10] Internet Engineering Task Force RFC 791 Internet Protocol, dated September, 1981.